EFFECTS OF SALINITY ON GROWTH AND SURVIVAL OF LARVAL AND JUVENILE ALLIGATOR GAR *Atractosteus spatula*, AND ON PLASMA OSMOLALITY OF NON-TELEOST ACTINOPERYGIIAN FISHES

A Thesis

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in Partial Fulfillment
of the Requirements for the Degree
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By
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CERTIFICATION

This is to certify that the thesis entitled "Effects of salinity on growth and survival of larval and juvenile alligator gar *Atractosteus spatula*, and on plasma osmolality of non-teleost Actinoperygiian fishes" submitted for the award of Masters of Science to Nicholls State University is a record of authentic original research conducted by Mark David Suchy under our supervision and guidance and that no part of this thesis has been submitted for the award of any other degree, diploma, fellowship, or other similar titles.

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ABSTRACT

Due to declining populations, there is a growing interest in developing aquaculture techniques for alligator gar *Atractosteus spatula* to restore native populations. Because salinity can influence growth rates, I subjected alligator gar to a series of trials to assess the effect of salinity on growth and survival of larval and juvenile alligator gar. All inferences are based on alpha = 0.05. Yolk-sac alligator gar were exposed to 0, 2, 4, 6, 8, 10, 12, or 14 ppt salinity for five days (5 individuals per tank; 3 tank's per treatment). All larvae in treatments > 8 ppt died and all larvae in treatments < 8 ppt survived. Survival in the 8 ppt treatment was 13.3 ± 11.6 %, and surviving individuals in the 8 ppt treatments were shorter and weighed less than fish in the lower salinity treatments. To determine the effect of salinity on growth and survival, 20 d old juvenile alligator gar were reared in 0, 4, 8 or 12 ppt for 31 days (3 rep's per treatment). Growth was greatest for the 4 and 8 ppt treatments and least for the 0 and 12 ppt treatments. Also, survival was greatest for the 4 ppt treatment compared to the 0 and 12 ppt treatment. A second growth trial exposed 50 d old juvenile alligator gar to 0, 6, 12, or 18 ppt salinity for 27 days, and fish in the 0 ppt treatment grew the fastest, with no difference in survival rates among treatments. Higher temperatures for the second trial may have led to the ambiguous results between the two growth trials. To better understand the physiology of salt tolerance, juvenile alligator gar, spotted gar, *Lepisosteus oculatus*, paddlefish, *Polyodon spathula*, and lake sturgeon, *Acipenser fulvescens*, were exposed to various salinity treatments with or with an acclimation period. Based on plasma osmolality and survival, an acclimation period allows alligator gar and spotted gar to tolerate a higher salinity level, but there is no acclimation effect on paddlefish and lake sturgeon. Alligator gar have a greater salinity tolerance (up to 37 ppt), than spotted gar (up to 30 ppt), lake sturgeon (up to 14 ppt), and paddlefish (up to 13 ppt). Results of this study will provide fisheries managers important information regarding culture, transport, and stocking these species.

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INTRODUCTION

The alligator gar *Atractosteus spatula* is a member of the order Lepisosteiformes and is the largest member of the family Lepisosteidae, which includes seven extant species in two genera *Atractosteus* and *Lepisosteus*. The genus *Atractosteus* contains alligator gar, Cuban gar *A. tristoechus* and tropical gar *A. tropicus* and the genus *Lepisosteus* contains spotted gar *L. oculatus*, shortnose gar *L. platostomus*, longnose gar *L. osseus*, and Florida gar *L. platyrhynchus.* The Lepisosteiformes are members of the infraclass Holostei, which possess ancient, less derived characteristics relative to the teleosts.

All gar species have interlocking armor-like ganoid scales and posterior located dorsal and anal fins with a modified heterocercal tail (Suttkus 1963; Ross 2001). Gar breathe atmospheric air using a highly vascularized physostomous swim bladder, allowing gar to live in oxygen deprived water (Suttkus 1963; Ross 2001). One defining characteristic of *Atractosteus* is a dual row of teeth on the upper jaw (Suttkus 1963; Page and Burr 1991). Adult alligator gar color varies from brown to olive dorsally and to cream ventrally (Suttkus 1963; Ross 2001). Adult alligator gar are commonly found in freshwater, but can be found in full strength sea water (Goodyear 1966; Helfman et al. 1997; Ross 2001). Alligator gar are widely distributed in rivers and lakes of the Mississippi River drainage and along the Gulf of Mexico coast from Florida to Veracruz, Mexico (Suttkus 1963; Álvaresz del Villar 1970; Wiley 1976; Lee and Wiley 1980; Page and Burr 1991, García de León et al. 2001; Ross 2001).

Adult alligator gar typically spawn from April to June in vegetated shallow, still water (Suttkus 1963; Echelle and Riggs 1972). Alligator gar eggs are adhesive and typically adhere to submerged aquatic vegetation, and hatch approximately 48 hours after fertilization at 31 °C (Aguilera et al. 2002). Similar to tropical gar, alligator gar eggs are cream in color and average approximately 4.3 ± 0.3 mm in diameter (Aguilera et al. 2002). At hatching, larval alligator gar are approximately 7 mm long (total length; TL), have an adhesive suctorial disc to remain attached to substrate, and feed endogenously on yolk-sac contents (Simon and Wallus 1989; Mendoza et al. 2002a; 2002b). Larval alligator gar begin exogenous feeding on zooplankton between 12.5 and 22.5 mm, and rely entirely on exogenous feeding after reaching 22 mm, when the yolk-sac contents are completely absorbed (Mendoza et al. 2002a). Larval and juvenile alligator gar have relatively fast growth rates, growing up to1.55 mm/day for the first 10 days after hatch (DAH) and up to 5.6 mm/day after 10 DAH at 28 °C (Mendoza et al. 2002a; 2002b).

Alligator gar populations have declined because of misconceptions by anglers and biologists, habitat loss and fragmentation, and recent commercial and recreational fishing pressure (Scarnecchia 1992; Ferrara 2001; Aguilera et al. 2002; Mendoza et al. 2002a; 2002b). Misconceptions were based on the belief that gar mainly consume sport fish; however, research has found that gar prey mainly on nongame fish (Hay 1894; Goodyear 1967; Pearson et al. 1979; Scarnecchia 1992). Habitat loss and fragmentation is occurring throughout the alligator gar range due to anthropogenic factors, causing populations to decline (Ferrara 2001). Stocking programs using hatchery reared alligator gar are currently used to restock depleted natural populations in Mississippi, Kentucky, Tennessee and Arkansas (personal communication, Ricky Campbell, Private John Allen

National Fish Hatchery, Tupelo, Mississippi). However, little research has been conducted on methods to increase overall growth and production of alligator gar so that reared fish can be used both for human consumption and to restock natural populations.

Alligator gar can tolerate higher levels of ammonia and nitrite, lower levels of dissolved oxygen, a wider range of salinity, and have a faster growth rate than many other fishes, making alligator gar a good candidate for aquaculture (Goodyear 1966; Helfman et al. 1997; Mendoza et al. 2002a; Boudreaux et al. 2007a; 2007b). Alligator gar can also tolerate stressful living conditions, and can be reared solely on artificial feed, which allows for easy husbandry (Mendoza et al. 2008). Although alligator gar can tolerate a wide range of water quality, each water quality variable probably has an optimum level that is least stressful. If any water quality variable shifts from the optimal level, the fish may become stressed, leading to a reduced growth rate (Vijayan and Leatherland 1988; Deng et al. 2002; Martínez-Palacios et al. 2002). If an optimum point for each water quality variable can be determined, production efficiency may be increased by managing culture systems for optimal growth.

Metabolic scope is defined as the difference between active and standard metabolism and reflects the amount of energy available for growth (Fry 1947). Neill and Bryan (1991) describe metabolism as a physiological engine that powers activities such as swimming, reproduction, and growth. When this "physiological engine" operates under sub-optimal conditions (i.e. temperature, oxygen, salinity, or ammonia) energy is diverted from growth to maintain homeostasis (Neill and Bryan 1991). Although there is an energetic cost to maintain internal osmolality, the cost increases as environmental salinity moves away from the optimal range. Optimal salinity varies among fish species but as salinity levels change, the energetic cost of osmoregulation changes. Fish that are reared at their optimal salinity level have reduced osmoregulatory energy demands, which leaves energy available for other activities, such as growth

Estuarine fish species are subjected to daily salinity shifts due to rain, tidal or wind events. Daily shifts in salinity can cause stress and even mortality for fish not adapted to variable conditions (Foil and Kűltz 2007). Marine fish, such as Atlantic halibut *Hippoglossus hippoglossus,* often have higher growth rates at salinity levels that are lower than full strength seawater (35 ppt): whereas freshwater fish (i.e. silver perch, *Bairdiella chrysoura*, blacknose silverside, *Chirostoma promelas*, rainbow trout, *Oncorhynchus mykiss*, striped bass, *Morone saxatilis*, and gulf sturgeon, *Acipenser oxyrinchus desotoi* often have higher growth rates at salinity levels higher than 0 ppt (Kibria et al. 1999; Altinok and Grizzle 2001; Boeuf and Payan 2001; Imsland et al. 2008; Martinez-Palacios et al. 2008). Martinez-Palacios et al. (2008) found that salinity from 0 to 35 ppt had no effect on blacknose silverside embryo development up to the eyed stage, but the hatching rate was reduced at salinities above 15 ppt. After hatching, blacknose silversides can survive a salinity change from 0 to 5 ppt without an acclimation period; however, if allowed to slowly acclimate they can survive up to 15 ppt (Martinez-Palacios et al. 2008). Although the blacknose silverside is a freshwater species, their maximum growth rate occurs at salinities between 5 and 15 ppt. Other freshwater species often have maximum growth rates in salinities between 4 and 8 ppt (Kibria et al. 1999; Martinez-Palacios et al. 2008). Some marine species such as flounder *Paralichthys orbignyanus* have reduced growth rates in freshwater (salinity <1.0 ppt), but have increased growth rates at salinities less than full strength seawater (Sampaio and

Bianchini 2002). Although optimal salinity for growth varies among species, salinity can have a significant effect on growth for many species.

Most fish are osmoregulators and maintain a relatively constant internal concentration of dissolved substances that is different from their surroundings (Moyle and Cech 1988). Plasma osmolality typically ranges between 370-480 mOsm for marine teleost fish, and 260-330 mOsm for freshwater teleost fish; however, environmental salinity can affect the plasma osmolality of fishes (Jobling 1995; Sampaio and Bianchini 2002). Although total energy expenditures of osmoregulation can account for as much as 20-50% of daily energy needs for some species (Rao 1968; Nordlie and Lefler 1975; Nordlie 1978; Furspan et al. 1984; Noedlie et al. 1991; Toepefer and Barton 1992), osmoregulation in other fish species requires very little energy (Morgan and Iwama 1991; Overton and Van den Avyle 2005). Osmoregulatory energy demands decrease if the osmolality of the surrounding water is similar to the internal plasma osmolality of a fish, although not all fish species have the fastest growth rates in iso-osmotic salinities (Morgan and Iwama 1991; Boeuf and Payan 2001; Imsland et al. 2008).

Rearing fish at optimum salinity reduces standard metabolic rate, which may provide more energy for growth (Neill and Bryan 1991). Also, fish lose the ability to osmoregulate, become stressed, and may die if the environmental salinity is too far from the optimal level. Determining salinity levels where osmoregulatory demands are minimal may maximize growth of certain fish species (Marshall et al. 1999; Sampaio and Bianchini 2002).

Goal:

The goals of this study was to determine the effects of salinity on growth rate, survival rate, and plasma osmolality of larval and juvenile alligator gar reared in recirculating systems and fed a commercially available diet, and to determined at what salinity juvenile alligator gar, spotted gar, paddlefish *Polyodon spathula*, and lake sturgeon *Acipenser fulvescens* lose the ability to regulate plasma osmolality.

Objectives:

1. Compare the growth and survival of yolk-sac larval alligator gar reared at salinities of 0, 2, 4, 6, 8, 10, 12, or 14 ppt.
2. Compare growth and survival of juvenile alligator gar reared at 0, 4, 8, or 12 ppt in recirculating culture systems from 20-51 DAH.
3. Compare growth and survival of juvenile alligator gar reared at 0, 6, 12, or 18 ppt in recirculating culture systems from 50-80 DAH.
4. To determine the effect of acclimation on the ability to maintain plasma osmolality at various salinities for alligator gar, spotted gar, paddlefish, and lake sturgeon.
5. To determine the 96 hour median-lethal concentration (LC50) of salinity for juvenile alligator gar.

METHODS

Water Quality

Water quality was measured daily for all trials unless otherwise stated. Total ammonia-nitrogen (TAN; mg/L), was measured using the Nesslerization method and nitrite-N (mg/L) was measured with the AZO-dye method. A Hannah Instrument pH meter was used to measure pH. Temperature (°C), dissolved oxygen (DO; mg/L), specific conductance (µs/cm), and salinity (ppt) were measured with a handheld temperature-oxygen-conductivity-salinity meter (Yellow Springs Instrument, Yellow Springs, Ohio). Salinity levels were obtained by using Instant Ocean Sea Salt and water changes were done when TAN > 5 mg/L, nitrite-n > 5 mg/L to maintain acceptable water quality (TAN < 12.15, salinity > 0.1) based on Boudreaux et al. (2007a; 2007b)

Experimental Tank Description

Three types of tanks were used for most trials and were labeled as: 1) greenhouse tanks, 2) holding tanks, and 3) laboratory tanks. Each greenhouse tank (n=12) consisted of a 95 L tank containing 60 L of water, with a center mounted bulkhead, which drained into a 19 L sump equipped with a 946 L/h pump (Figure 1). Each sump was monitored daily and maintained with at least 16 L of water and flow in each system was restricted to 60 L/h using valves. Fish were exposed to a natural photoperiod and daytime maximum temperature fluctuations were mitigated by a mist fan system, shade cloth (90% cover), and fans.

Each laboratory tank (n=3) consisted of a 154 L round static tank system containing 128 L of water, equipped with air stones for aeration. Each holding tank

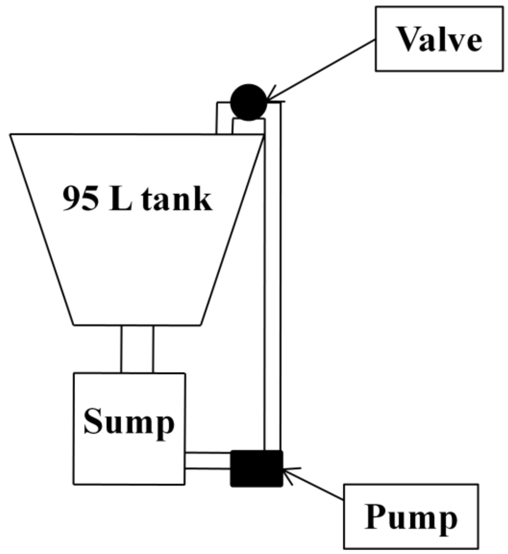

Figure 1. Schematic diagram of the greenhouse single tank recirculation systems used for the juvenile alligator gar growth trials.

(n=2) consisted of a 2,268 L round tank system equipped with air stones, and a recirculating bead filter system. The laboratory and holding tanks were indoor in the Bayousphere Research Laboratory at Nicholls State University, Thibodaux, Louisiana, were exposed to a natural photoperiod (10:14 hours) from artificial lighting and maintained at approximately 24 °C.

Measuring Plasma Osmolality (mOsm)

To measure plasma osmolality, fish (n=3/treatment) were sacrificed and blood samples were obtained from the caudal artery. Blood was captured using 70 µl Fisherbrand microhematocrit heparinized capillary tubes to prevent blood clotting, which were immediately spun in an Adams micro-hematocrit centrifuge (Clay-Adams Inc., New York) for three minutes. The capillary tubes were etched with a file and broken to separate the plasma from the red blood cells, and 10 µl of plasma was transferred to a disposable pipette. The plasma was then transferred to a 10 µl sample tube and inserted into an Osmette II 5005 automatic osmometer for analysis.

Alligator gar yolk-sac larvae growth and survival trial

To determine the effect of salinity on alligator gar yolk-sac larval growth and survival, individuals were exposed to 0, 2, 4, 6, 8, 10, 12, or 14 ppt for five days in the Bayousphere Research Laboratory. Alligator gar yolk-sac larvae were obtained by spawning broodstock at Golden Ranch Plantation in Gheens, Louisiana, and were maintained in aerated recirculating tanks. The trial was conducted using 1.5 L static plastic tanks set up in triplicate for each treatment of five yolk-sac larvae alligator gar transferred directly from 0 ppt to the treatment salinity. Yolk-sac larvae were not fed during the trial. Dry weight was determined by drying fish for 5 days at 37.7 °C (g; n=50) and total length (TL; mm) was measured before the trial began for each fish. Lengths and dry weights were measured at the end of the trial for each surviving individual. Mortalities were counted, recorded, and removed daily. Only individuals surviving the entire trial were included for final treatment comparisons. Dissolved oxygen, specific conductance, temperature, and salinity were measured at the beginning and conclusion of the trial.

Salinity effect on growth and survival of 20 DAH juvenile alligator gar

To determine the effect of salinity on growth and survival of small juvenile alligator gar, 20 DAH fish (wet weight = 0.085 ± 0.009 g) were exposed to 0, 4, 8, or 12 ppt in the greenhouse tanks for 31 days. The fish used for this trial were obtained by spawning broodstock at Golden Ranch Plantation in Gheens, Louisiana, and were maintained in aerated recirculating tanks, at 28.14 ± 2.14 °C and maintained at 0 ppt. Mortalities were counted, recorded and removed daily.

Fish were acclimated with a drip tube to specific salinity treatment levels by increasing salinity 4 ppt daily (Martinez-Palacios et al. 2008). After acclimation fish were transferred into treatment tanks (n=300; 5/L). At the start of the trial 50 fish were weighed (mg) and measured (mm; TL) from each salinity treatment using a scale and digital calipers. During the acclimation period mortalities were counted, recorded, and removed daily. The fish were fed 10% body weight daily (Table 1), divided equally into three feedings (0900, 1200, and 1500 hrs) from 20-33 DAH. Because fish were unable to consume all of the feed, the feed rate was lowered to 5% body weight daily, divided

Table 1. Feed type, size (mm), percent protein, percent lipid, feeding rate (% body weight per day), and age (DAH) for juvenile alligator gar exposed to 0, 4, 8, or 12 ppt in recirculating culture systems.

Feed	**Size**	**Protein**	**Lipid**	**Feed rate**	**Age**
Silver Cup Trout fry feed granulated crumble #2	0.84-1.38	48	14	10	20-24
AquaMax Grower 400	2.4	45	16	10	24-33
AquaMax Grower 400	2.4	45	16	5	33-51

equally into three feedings from 33-51 DAH (Table 1). Feed amount was adjusted every four days based on the mean weight of 20 individuals per tank, and mortalities were counted, recorded and removed daily. At 51 DAH all fish were removed from the trial, weighed (g), and measured (mm; TL).

Salinity effect on growth and survival of 50 DAH juvenile alligator gar

To determine the effect of salinity on growth and survival of 50 DAH large juvenile alligator gar (127.7 ± 7.7 mm; 8.7 ± 1.1 g), stocked at 30 (0.5/L) fish per tank were exposed to either 0, 6, 12, or 18 ppt for 28 days in the greenhouse tanks. The fish were obtained from the Private John Allen National Fish Hatchery in Tupelo, Mississippi. Tanks were maintained at ambient temperature (29.0 ± 2.5 °C) and mortalities were counted, recorded and removed daily. Specific growth rate (SGR) was determined as

$$SPG = 100[(\text{Ln } W_t - \text{Ln } W_i)/t]$$

where (W_t = mean final dry weight; W_i = mean initial dry weight; t = trial length) using dry weights. Feed conversions ratio (FCR) was determined as

$$FCR = [\text{feed intake / weight gain}]$$

using dry weights of fish and feed. Mean dry weights (n=15/treatment) were determined by drying fish for 5 days at 37.7 °C.

Fish were acclimated to their specific salinity treatment levels by increasing salinity 6 ppt per day prior to trial initiation. Each fish was measured using a scale (g) and ruler (mm; TL) at the beginning of the trial. The fish were fed 8% body weight (Table 2), divided equally among three daily feedings from 50-62 DAH. Because fish

Table 2. Feed type, size (mm), percent protein, percent lipid, feeding rate (% body weight per day), and age (DAH) for juvenile alligator gar exposed to 0, 6, 12, or 18 ppt in recirculating culture systems.

Feed	Size	Protein	Lipid	Feed rate	Age
AquaMax Grower 400	2.4	45	16	8	50-62
AquaMax Grower 400	2.4	45	16	4	62-63
AquaMax Grower 500	4.8	41	12	4	63-73
AquaMax Grower 600	6.4	41	12	4	73-78

were unable to consume all of the feed, the feeding rate was lowered to 4% body weight, divided equally among three daily feedings for 62-77 DAH fish (Table 2). The feed amount was adjusted every two days based on the mean wet weight of ten individuals per tank. Mortalities were counted, recorded and removed daily. At 80 DAH all fish were weighed and measured.

Effect of acclimation to salinity on plasma osmolality

To determine the effects of environmental salinity on the ability to maintain plasma osmolality for juvenile alligator gar, spotted gar, paddlefish, and lake sturgeon maintained at 0 ppt, fish were exposed to various salinities, in increments of 4 ppt (i.e. 0, 4, 8, 12, etc.), for 24 hours without an acclimation period. The maximum salinity treatment was reached when 100% mortality occurred (Table 3). Trials for juvenile alligator gar, paddlefish, and lake sturgeon were conducted in laboratory tanks (n=3) and spotted gar trials were conducted in 75 L aerated aquariums (n=3).

To determine the effects of acclimation to environmental salinity on the ability to maintain plasma osmolality for juvenile alligator gar, spotted gar, paddlefish, and lake sturgeon, fish were subjected to a 1 ppt/day increase in salinity until mortality occurred or all fish were used (Table 3). Trials for juvenile alligator gar, and lake sturgeon were conducted in the laboratory tanks, trials for paddlefish were conducted in the holding tanks and trials for spotted gar were conducted in 75 L aerated aquariums (n=3). Hurricane Gustav made landfall on 1 September 2008, and postponed the alligator gar trial for two weeks. As a result, the fish were held at 15 ppt for the entire two weeks, but no mortalities occurred during this time.

Table 3. Mean (±SD), weight (g), length (mm), and range of salinity (ppt) for the acclimated and non-acclimated trials for each species. Salinity was increased 1 ppt/day for the acclimated trials and was increased 4 ppt/day for the non-acclimated trials.

Species	**Weight**	**Length**	**Acclimated**	**Non-acclimated**
Alligator gar	27.5 ± 10.1	198.6 ± 26	0 - 37	0 – 32
Spotted gar	4.0 ± 1.1	122 ± 10.5	0 - 30	0 – 16
Paddlefish	110.3 ± 39.5	377.4 ± 33.4	0 - 13	0 – 12
Lake sturgeon	3.9 ± 0.9	119.3 ± 8.4	1 - 14	0 – 12

Juvenile alligator gar were obtained by spawning broodstock at Golden Ranch Plantation in Gheens, Louisiana, and spotted gar were obtained by spawning broodstock at Nicholls State University, and were maintained in aerated recirculating tanks. Lake sturgeon, and paddlefish were obtained from the Private John Allen National Fish Hatchery in Tupelo, Mississippi, and were maintained under conditions similar to alligator gar and spotted gar. Fish were exposed to temperatures of approximately 24 °C, and water quality was maintained at acceptable levels for each species (Boudreaux et al. 2007a; 2007b).

Acute effects of a lethal dose of salinity on plasma osmolality

To determine the acute effect of a lethal salinity concentration on plasma osmolality immediately after exposure, fish were exposed to a lethal concentration of salinity without an acclimation period. Spotted gar were obtained by spawning broodstock at Nicholls State University, and were maintained in aerated recirculating tanks. Juvenile alligator gar, lake sturgeon, and paddlefish were obtained from the Private John Allen National Fish Hatchery in Tupelo, Mississippi, and were maintained in aerated recirculating tanks. Fish were kept at approximately 24 °C, and water quality was maintained at acceptable levels for each species (Boudreaux et al. 2007a; 2007b). Alligator gar (164.4 ± 10.8 mm; 16.2 ± 2.8 g) were transferred from 0 ppt to 34.3 ppt laboratory tanks, spotted gar (121 ± 7.6 mm; 4.2 ± 0.8 g) were transferred from 0 to 24 ppt laboratory tanks, lake sturgeon (126.7 ± 8.7 mm; 4.8 ± 1.0 g) were transferred from 0 to 16.2 ppt laboratory tanks, and paddlefish (410.3 ± 29.7 mm; 129.8 ±3 8.8 g) were transferred from 0 ppt to 14.2 ppt holding tanks. After transfer into the treatment tanks, three individuals were sacrificed every 30 minutes for the first two hours, and then three fish were sacrificed every hour until 100% mortality was reached. Salinity, TAN, nitrite-N, and pH was measured at the beginning of each trial.

96-hr median-lethal concentration (LC50)

To determine if the size of juvenile alligator gar affects salinity tolerance, two 96-hour LC50 trials were conducted with same age fish (55 - 65 DAH) of different weights. Juvenile alligator gar for the first trial were 5.3 ± 0.55 g, and 109.3 ± 3.31 mm, and juvenile alligator gar for the second trial were 20.1 ± 2.26 g, and 170.2 ± 6.61 mm. Juvenile alligator gar (N=1/tank; 6 replicates per treatment) for the first trial were maintained at 0 ppt, and exposed to 12, 16, 18, 19, 20, or 24 ppt without an acclimation period in 19 L aerated aquariums, containing approximately 15 L of water. Juvenile alligator gar (N=1/tank; 6 replicates per treatment) for the second trial were maintained at 0 ppt, and exposed to 12, 16, 20, 24, 28, or 32 ppt without an acclimation period in 19 L aerated aquariums, containing approximately 15 L of water. Mortalities were counted, recorded and removed daily.

Statistical Analysis

Final dry and wet weights, length, plasma osmolality, survival, temperature, pH, TAN, nitrite-n, salinity, and DO were subjected to analysis of variance (α=0.05) followed by Tukey's *post- hoc* test if needed to determine differences among salinity treatments. Analysis of covariance was used to compare growth rates.

RESULTS

Alligator gar yolk-sac larvae growth and survival trial

Alligator gar yolk-sac larvae survived all salinity treatments below 8 ppt, and no alligator gar yolk-sac larvae survived any salinity treatment above 8 ppt (Figure 2). Mean (±SD) percent survival for the 8 ppt treatment was 13.3 ± 11.6 (Figure 2). Dry weight was greater for the 4 ppt treatment than the 0, 2, and 8 ppt treatments, and was lowest for the 8 ppt treatment compared to all other treatments that had mean percent survival greater than zero (Figure 3). Total length at the end of the experiment was lowest for the 8 ppt treatment, and did not differ among the 0, 2, 4, or 6 ppt treatments (Figure 4). Temperature for all treatments combined was 23.4 ± 0.11 °C, and did not differ among treatments. Dissolved oxygen for all treatments combined was 7.39 ± 0.21 mg/L, and was always greater than 7.0 mg/L for all tanks.

Salinity effect on growth and survival of 20 DAH juvenile alligator gar

Fish in all treatments gained weight during the trial; however, fish in the 4 and 8 ppt treatments gained more weight than fish in the 0 and 12 ppt treatments (Figure 5). Juvenile alligator gar weight at the end of the trial was greater for the 4 and 8 ppt treatments than for the 0 and 12 ppt treatments (Figure 6). Juvenile alligator gar length at the end of the trial was greater for the 8 ppt treatments than for 0 and 12 ppt treatments (Figure 7). Most mortality occurred during the first week of the experiment (Figure 8) and overall survival was not similar among treatments. Mortality was lower for the 4 ppt treatment (50.1 ± 0.06 %) than the 0 ppt (67.4 ± 0.08 %) and 12 ppt treatments (77.8 ± 0.03; Figure 9). Temperature and pH did not differ among treatments, but DO was

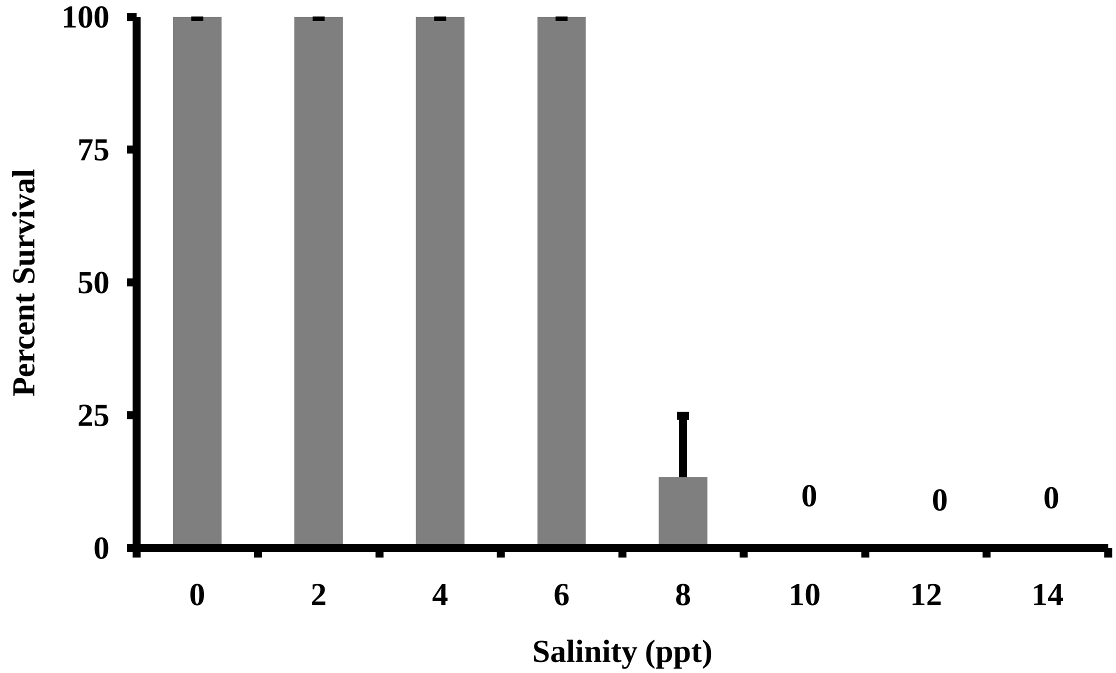

Figure 2. Mean (±SD) percent survival for alligator gar yolk-sac larvae exposed to 0, 2, 4, 6, 8, 10, 12 or 14 ppt salinity for five days. Trial was initiated with two DAH larvae alligator gar. There were no survivors in treatments greater than 8 ppt.

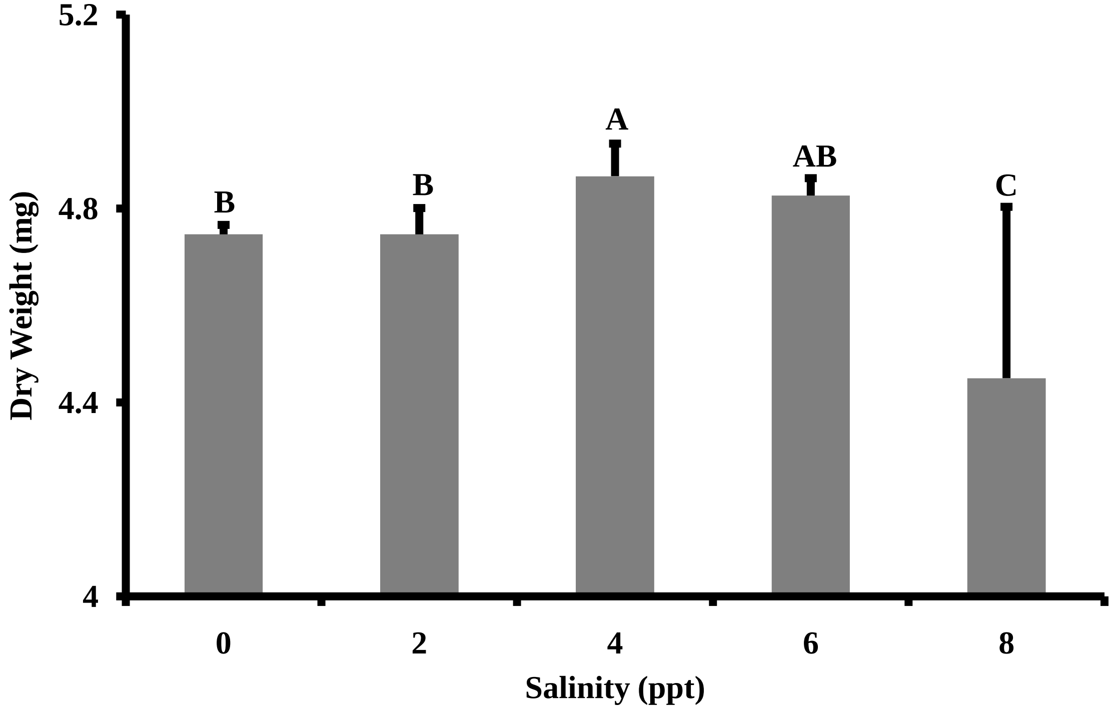

Figure 3. Mean (±SD) dry weight for alligator gar yolk-sac larval exposed to 0, 2, 4, 6, or 8 ppt salinity for five days. Means that share a common letter are similar.

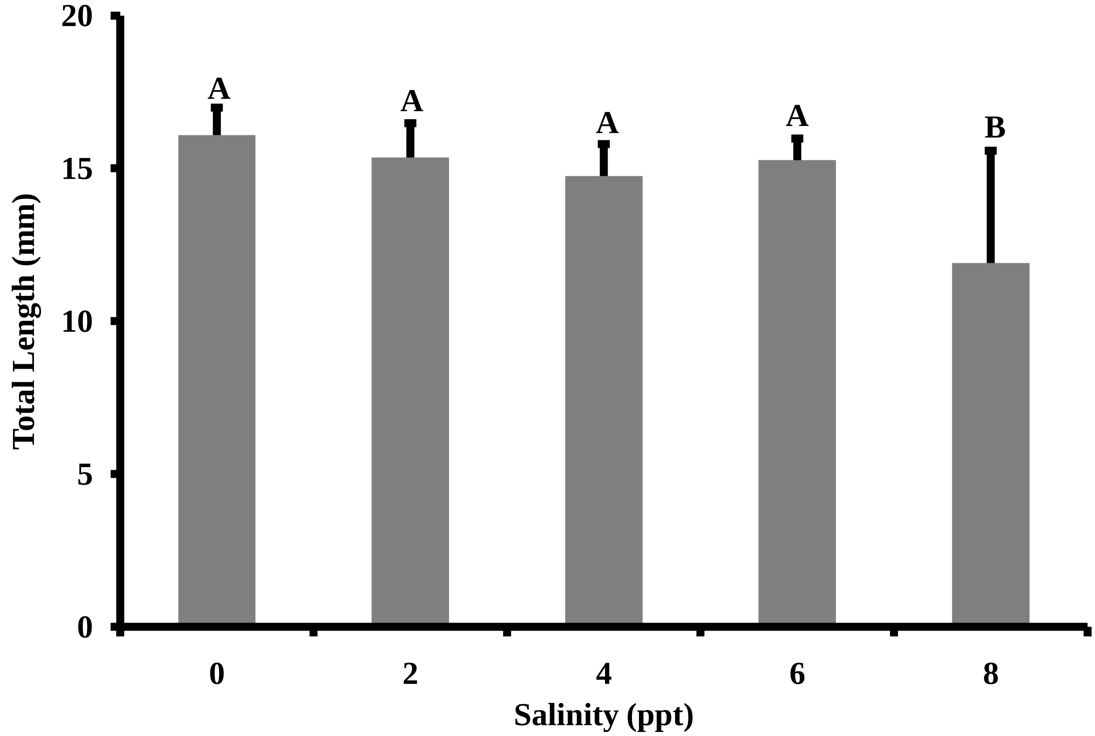

Figure 4. Mean (±SD) total length for alligator gar yolk-sac larvae exposed to 0, 2, 4, 6, or 8 ppt salinity for five days. Means that share a common letter are similar.

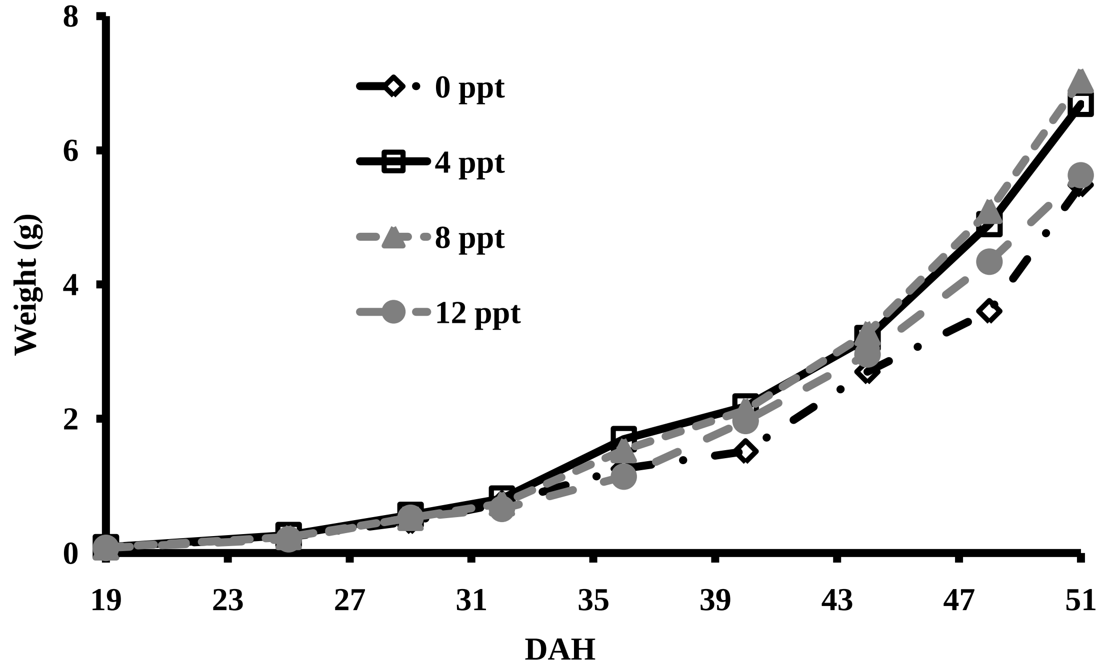

Figure 5. Mean weight of juvenile alligator gar exposed to 0, 4, 8 or 12 ppt for 19 DAH to 51 DAH.

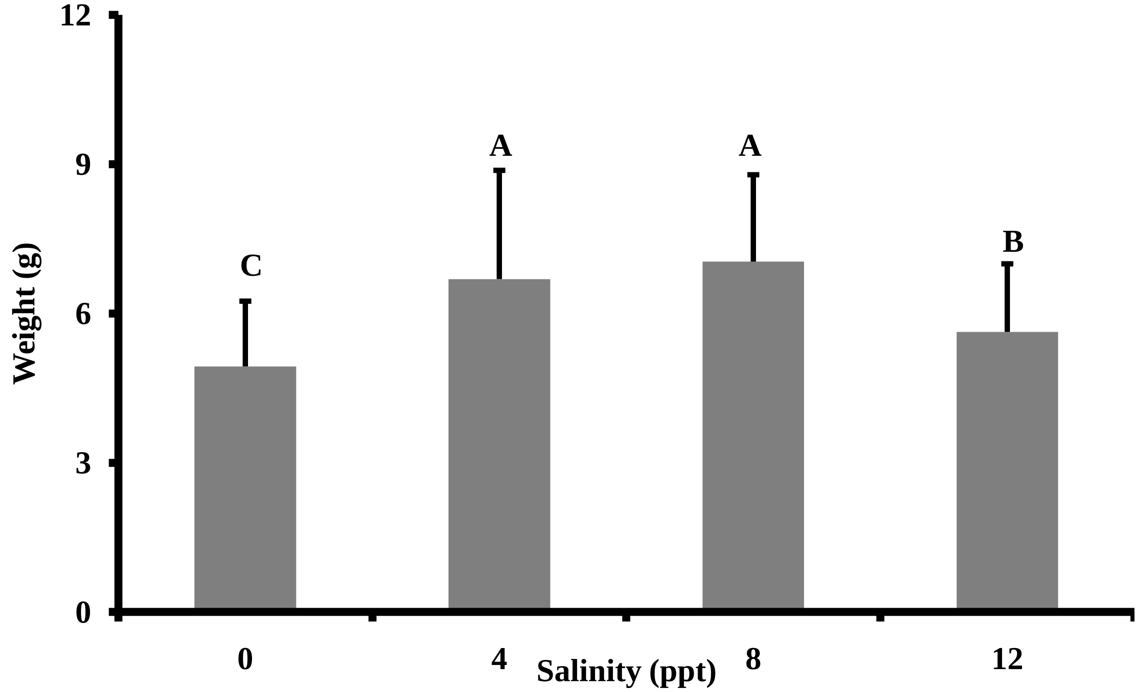

Figure 6. Mean (±SD) final weight of 51 DAH juvenile alligator gar exposed to 0, 4, 8 or 12 ppt in recirculating culture systems for 31 days. Means that share a common letter are similar.

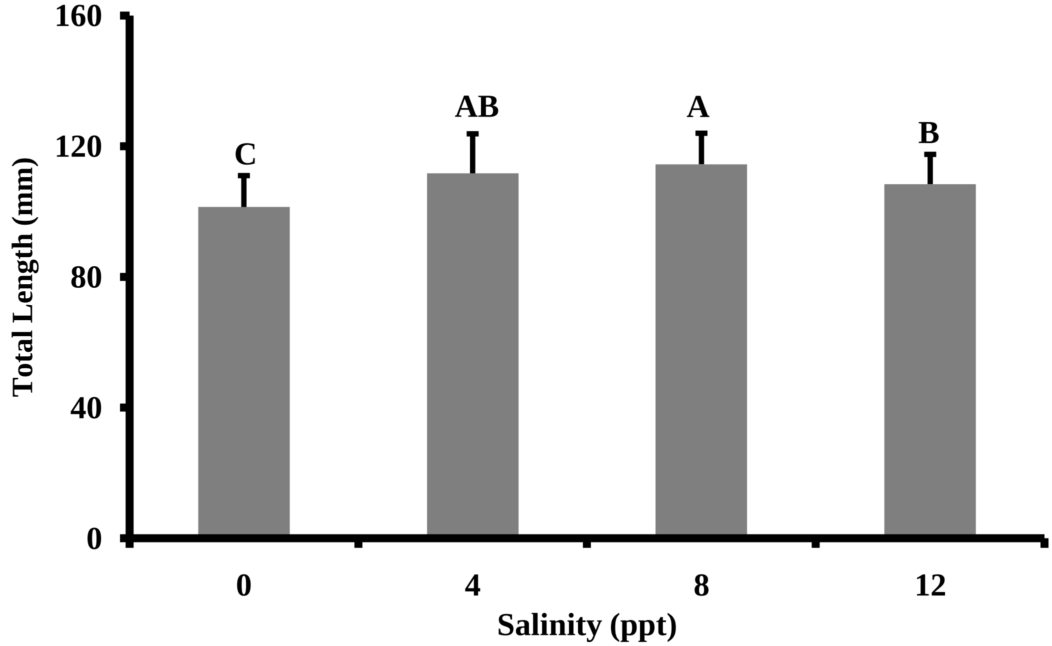

Figure 7. Mean (±SD) final total length of 51 DAH juvenile alligator gar exposed to 0, 4, 8 or 12 ppt in recirculating culture systems for 31 days. Means that share a common letter are similar.

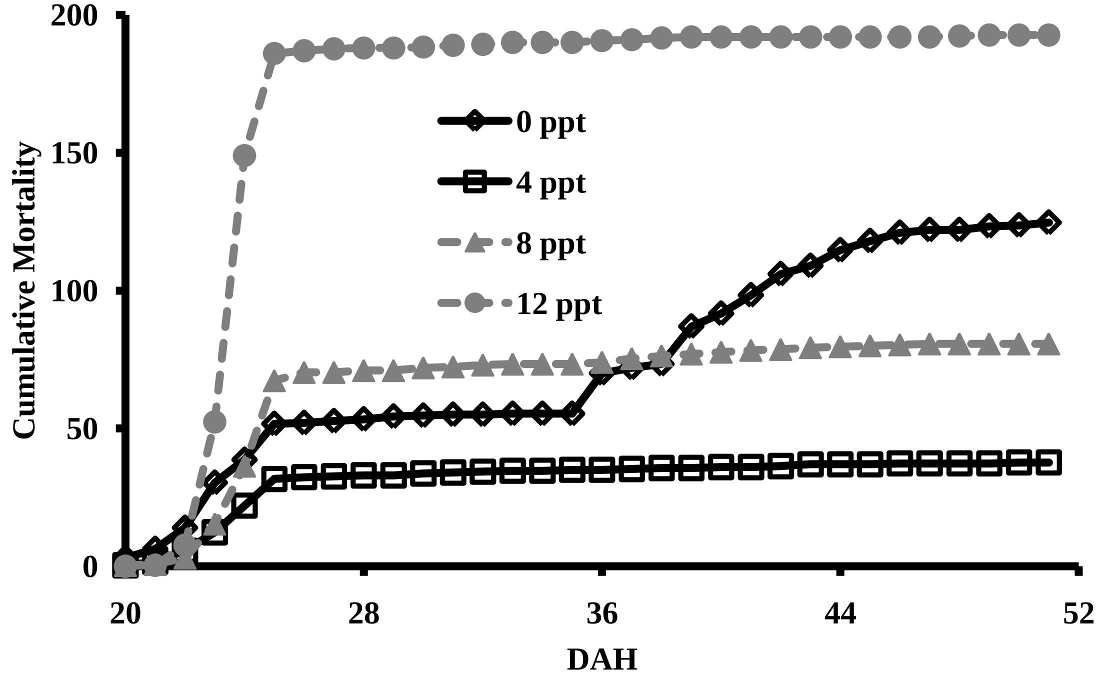

Figure 8. Cumulative mortality of juvenile alligator gar exposed to 0, 4, 8 or 12 ppt for 20 to 51 DAH.

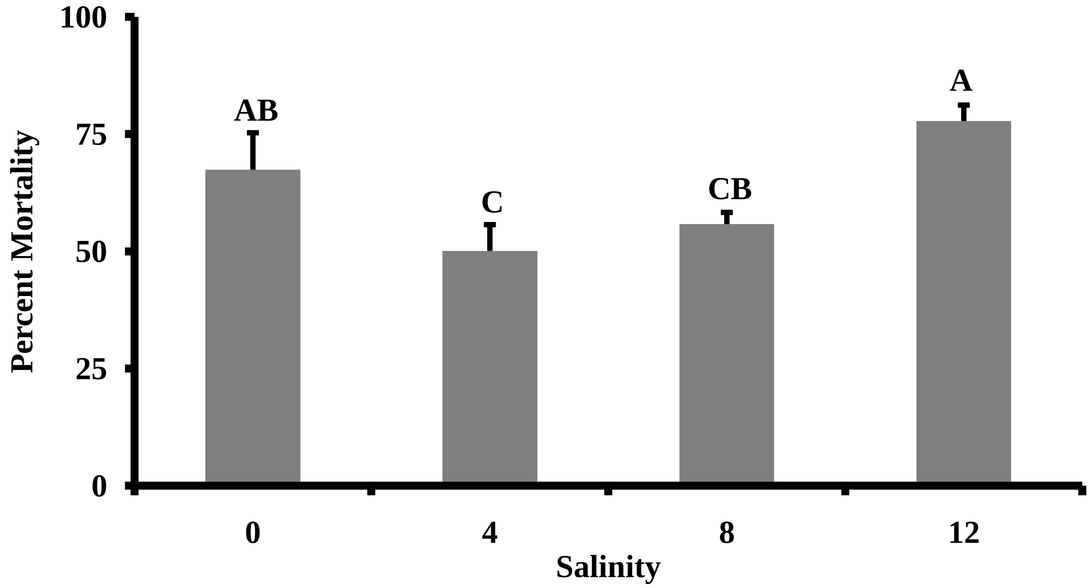

Figure 9. Mean (±SD) percent mortality of 51 DAH juvenile alligator gar exposed to 0, 4, 8, or 12 ppt in recirculating culture systems for 31 days. Means that share a common letter are similar.

greatest for the 0 ppt (5.4 ± 0.4 mg/L) and 12 ppt treatments (5.7 ± 0.3 mg/L; Table 4). Nitrite-N was the greatest for the 12 ppt treatments (2.8 ± 0.7), and TAN was the greatest for the 4 ppt treatment (8.2 ± 3.3 mg/L; Table 4).

Salinity effect on growth and survival of 50 DAH juvenile alligator gar

Fish in all treatments gained weight during the trial; however fish in the 0 ppt treatment gained more weight than fish in the 6, 12, or 18 ppt treatments (Figure 10). Juvenile alligator gar weight (Figure 11) and length (Figure 12) at the end of the trial was greater for the 0 ppt treatments than the 6, 12, or 18 ppt treatments. There was no difference in survival (92.7 ± 6.9 %) among treatments at the end of the trial (Figure 13). Specific growth rate ranged between 7.4 and 8.2 %, and did not differ among treatments (Figure 14). Feed conversion ratio was lower for the 0 ppt (3.1 ± 0.07) than the 12 ppt treatment (4.0 ± 0.3; Figure 15). Temperature, pH, and DO did not differ among treatments, but nitrite-N was the greatest for the 18 ppt treatments (3.9 ± 1.1 mg/L), and TAN was the greatest for the 6 ppt treatments (6.7 ± 1.0 mg/L; Table 5).

Effect of acclimation to salinity on plasma osmolality

Juvenile alligator gar exposed to 0, 4, 8 or 12 ppt for 24 hours without an acclimation period had lower plasma osmolality levels (314.5 ± 10.8 mOsm) compared to juvenile alligator gar exposed to 20, 24, 28, or 32 ppt for 24 hours (445 ± 36.1 mOsm; Figure 16). No mortalities occurred in treatments less than 28 ppt, 33% mortality occurred in the 28 ppt treatment, 66% mortality occurred in the 32 ppt treatment, and 100% mortality occurred in the 36 ppt treatment (Figure 17). Juvenile

Table 4. Mean (±SD) temperature (°C), pH, DO (mg/L), nitrite-N (mg/L), and TAN (mg/L) for growth, and survival trials for 20-51 DAH juvenile alligator gar. Means within rows that share a common letter are similar.

Parameters	**Salinity**			
	0	**4**	**8**	**12**
Temperature	28.2±0.5	28.0±0.7	28.2±0.1	28.1±0.2
pH	7.7±0.1	7.6±0.01	7.6±0.06	7.8±0.4
DO	5.4±0.4^{A}	4.1±0.3^{B}	4.6±0.5^{B}	5.7±0.3^{A}
Nitrite-N	0.86±0.92^{B}	0.77±0.18^{B}	0.8±0.5^{B}	2.76±0.65^{A}
TAN	5.38±1.0^{AB}	8.16±3.30^{A}	6.81±0.02^{AB}	4.11±0.11^{B}

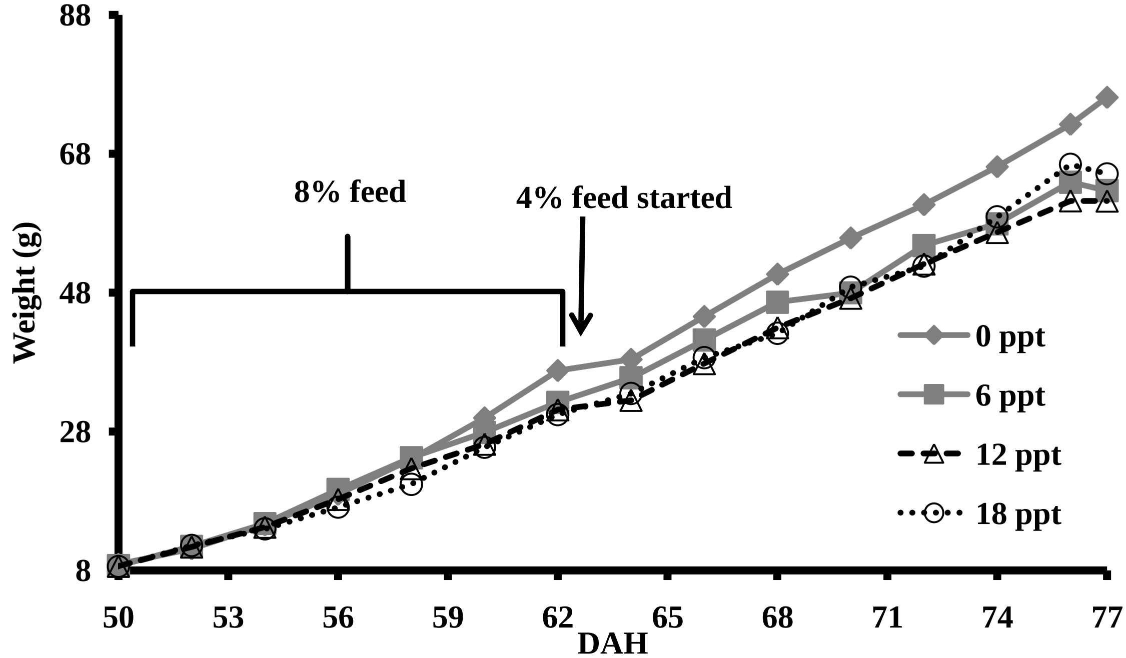

Figure 10. Mean weight of juvenile alligator gar 50-77 DAH exposed to 0, 6, 12, or 18 ppt salinity in recirculating culture systems.

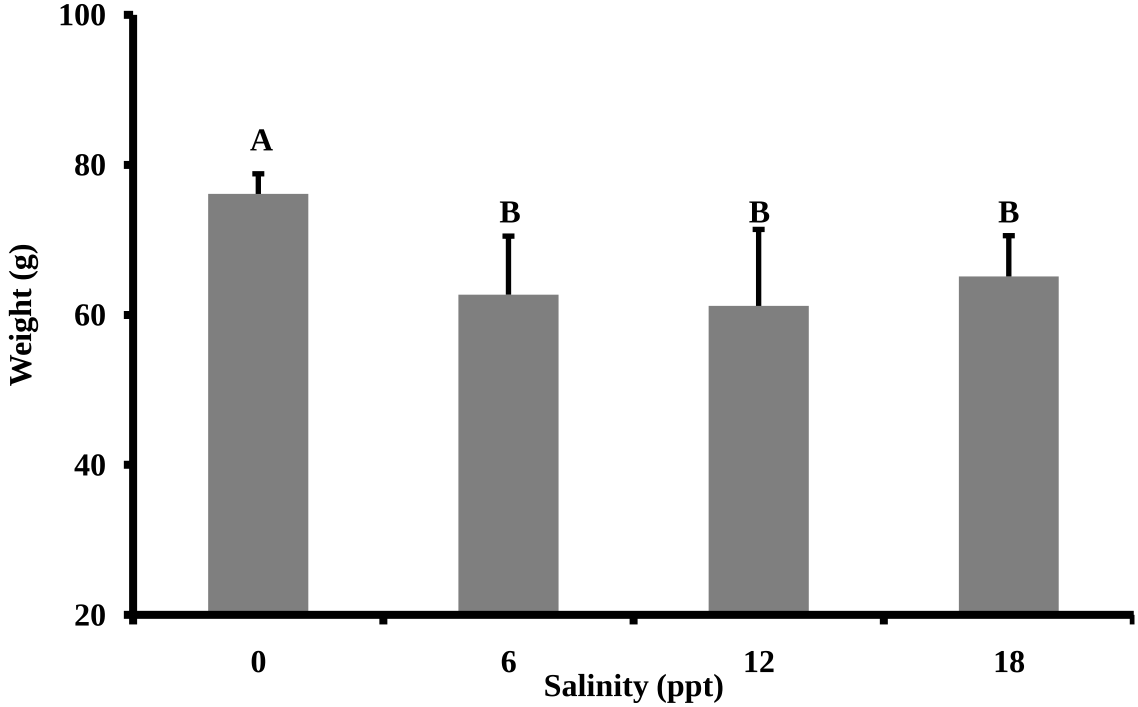

Figure 11. Mean (±SD) final weight of 50-77 DAH juvenile alligator gar exposed to 0, 6, 12 or 18 ppt in recirculating culture systems for 28 days. Means that share a common letter are similar.

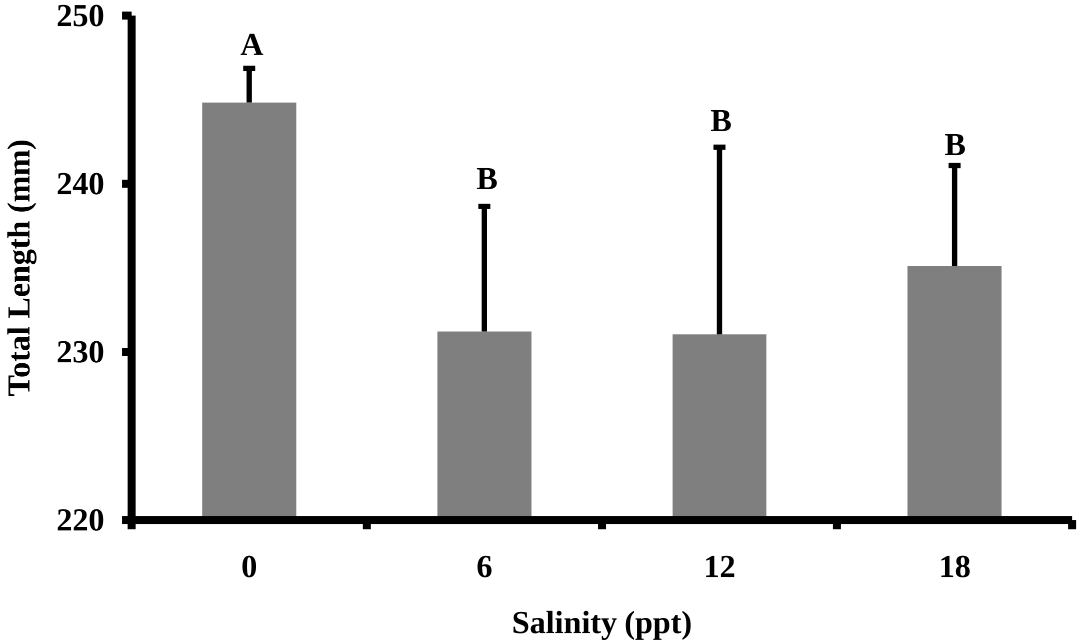

Figure 12. Mean (±SD) final total length of 50-77 DAH juvenile alligator gar exposed to 0, 6, 12 or 18 ppt in recirculating culture systems for 28 days. Means that share a common letter are similar**.**

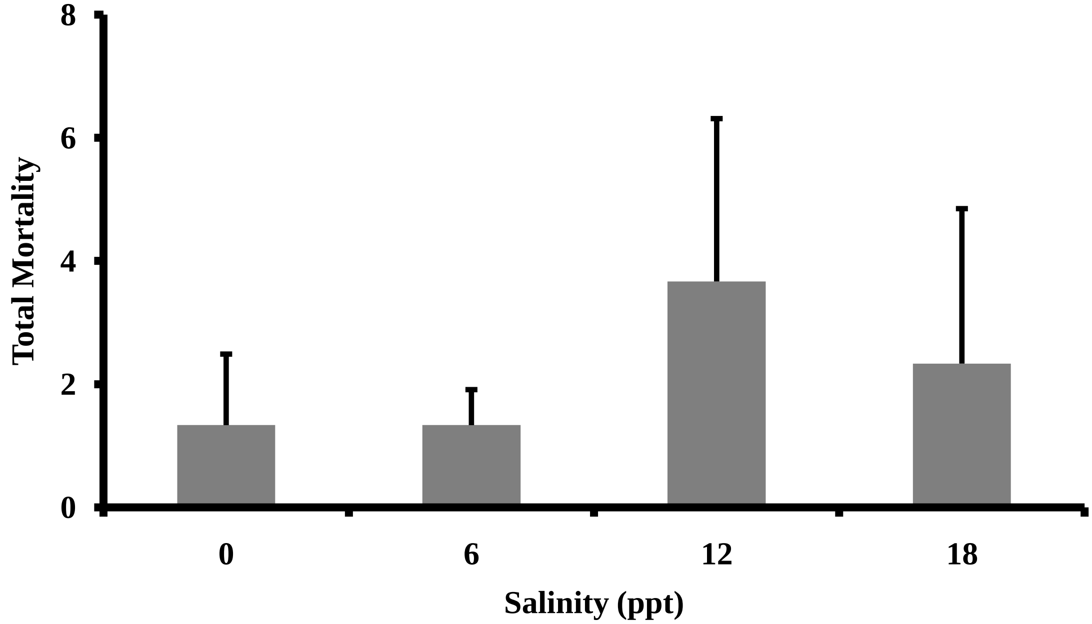

Figure 13. Mean (±SD) total mortality of 50-77 DAH juvenile alligator gar exposed to 0, 6, 12, or 18 ppt in recirculating culture systems for 28 days.

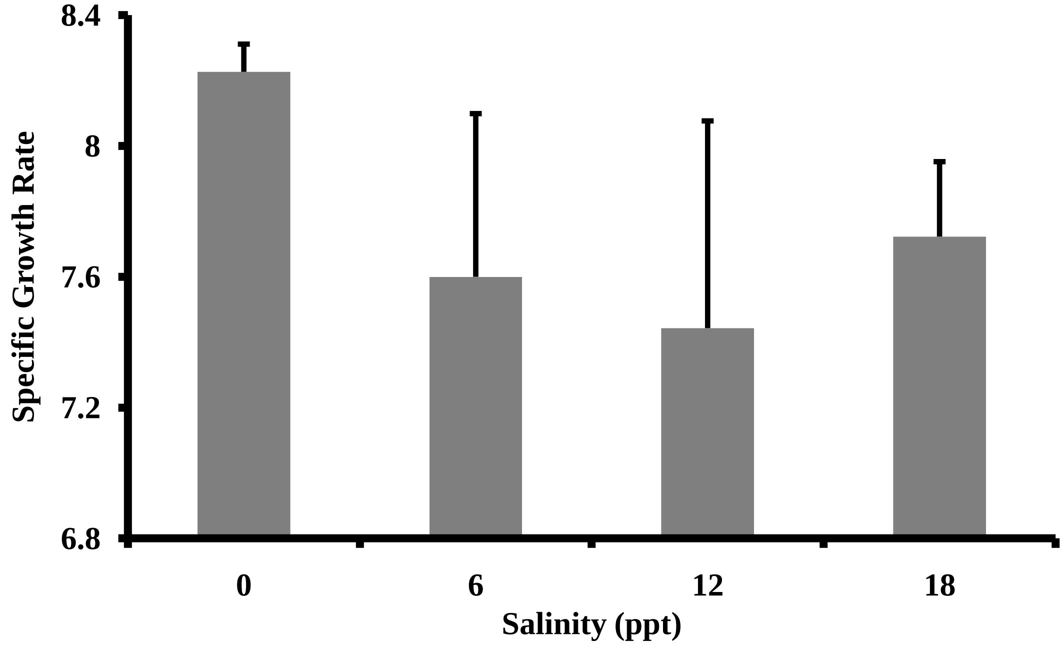

Figure 14. Specific growth rates of 50-77 DAH juvenile alligator gar exposed to 0, 6, 12, or 18 ppt in recirculating culture systems for 28 days.

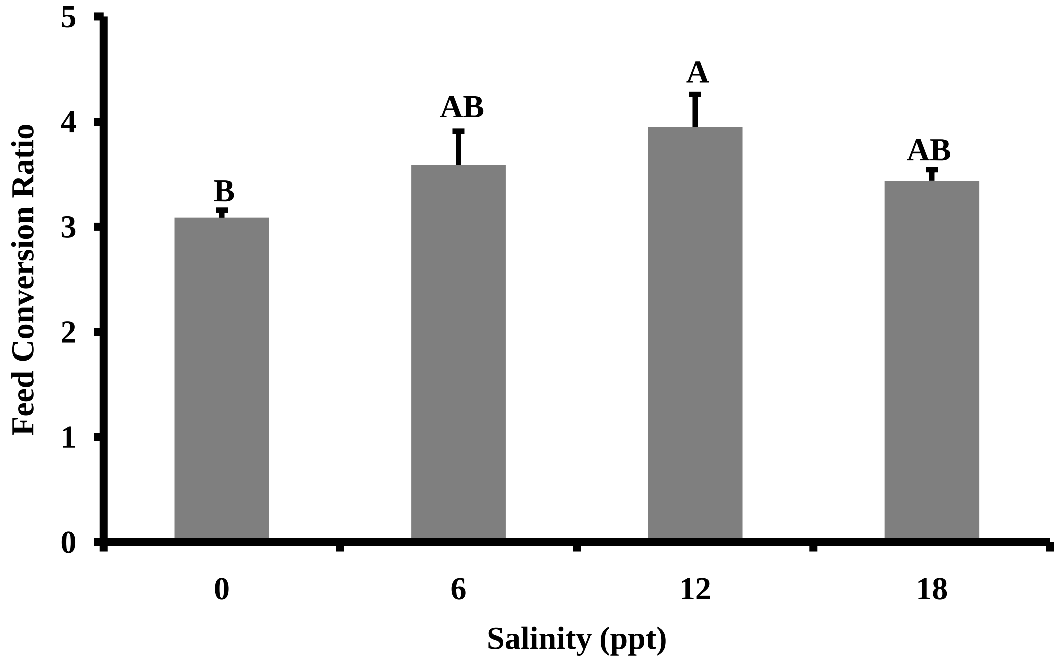

Figure 15. Mean (±SD) feed conversion ratio of juvenile alligator gar exposed to 0, 6, 12, or 18 ppt in recirculating culture systems for 28 days. Means that share a common letter are similar**.**

Table 5. Mean (±SD) temperature (°C), pH, DO (mg/L), nitrite-N (mg/L), and TAN (mg/L) for growth, and survival trials for 50-77 DAH juvenile alligator gar. Means within rows that share a common letter are similar.

Parameters	**Salinity**			
	0	**6**	**12**	**18**
Temperature	29±0.1	28.9±0.03	29±0.06	29.1±0.2
pH	7.1±0.04	7.1±0.02	7.1±0.01	7.1±0.03
DO	3.4±0.7	2.3±0.3	3.1±0.4	3.1±0.2
Nitrite-N	$2.77±1.32^{AB}$	$0.74±0.17^{B}$	$1.71±0.56^{AB}$	$3.86±1.11^{A}$
TAN	$3.35±1.46^{B}$	$6.75±0.95^{A}$	$3.03±1.59^{B}$	$2.88±0.56^{B}$

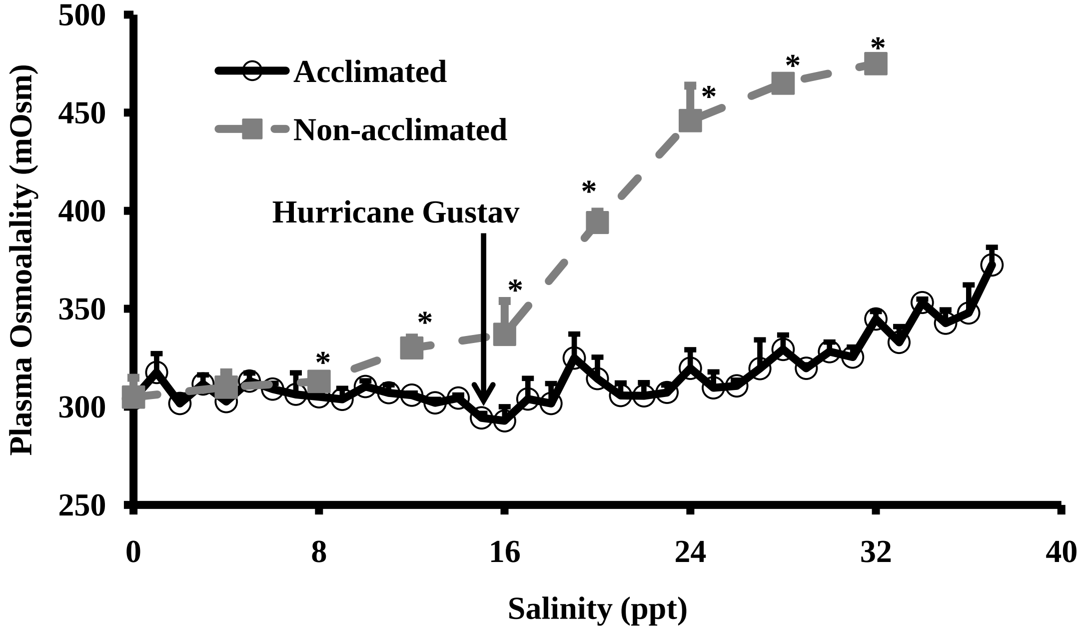

Figure 16. Mean (±SD) plasma osmolality of acclimated and non-acclimated juvenile alligator gar exposed to salinity levels for 24 hours. Open circles represent acclimated plasma osmolality, and closed squares represent non-acclimated plasma osmolality. Hurricane Gustav made landfall on 1 September 2008, and postponed research for two weeks. Means with an asterisk indicate a difference between trials.

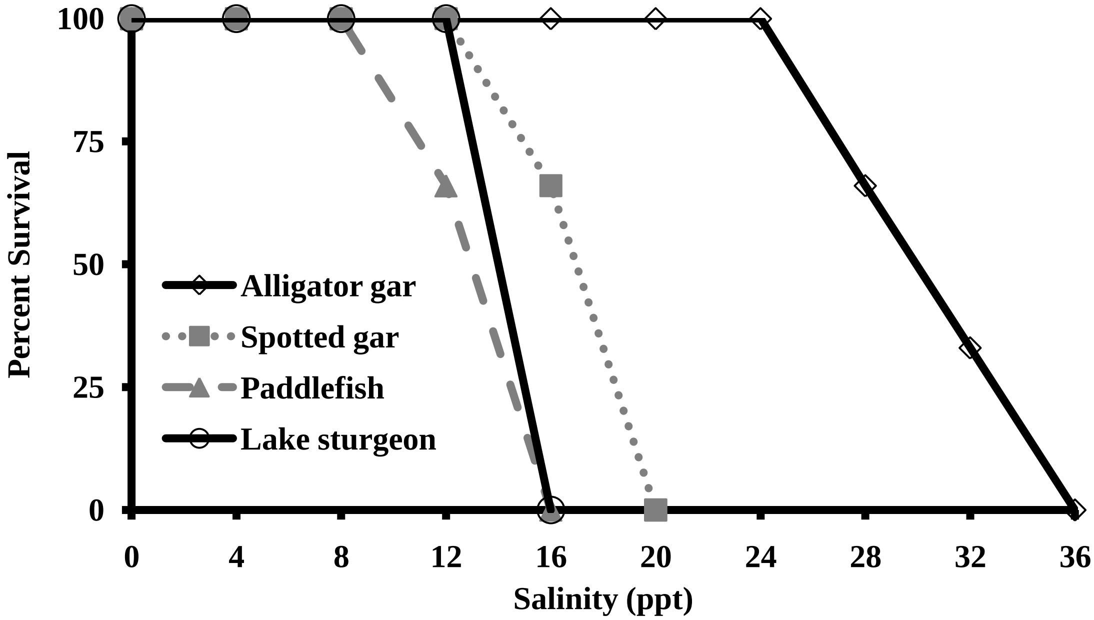

Figure 17. Percent survival of alligator gar, spotted gar, paddlefish, and lake sturgeon exposed to salinity levels in increments of 4 ppt for 24 hours without an acclimation period.

alligator gar exposed to one ppt increase in salinity per day had a slight day to day variation in plasma osmolality levels from 0 to 28 ppt (307.7 ± 9.12 mOsm); however, plasma osmolality increased as salinity was increased above 28 ppt, and was 372.3 ± 9.0 mOsm for the 37 ppt treatment (Figure 16). Hurricane Gustav made landfall on 1 September 2008, which prohibited data from being collected, and fish were maintained at 15 ppt for 14 days. No mortalities occurred during the acclimated trial. There was no difference between the plasma osmolality levels of juvenile alligator gar exposed to the acclimated and non-acclimated trials below 8 ppt (Figure 16).

Paddlefish exposed to 0 or 4 ppt for 24 hours without an acclimation period had lower plasma osmolality levels (249.3 ± 2.2 mOsm) compared to paddlefish exposed to 12 ppt (357.6 ± 7.5 mOsm) for 24 hours (Figure 18). No mortalities occurred below 12 ppt, 33% mortality occurred at 12 ppt, and 100% mortality occurred in the 16 ppt treatment (Figure 17). Paddlefish exposed to an increase of one ppt per day had slight day to day variation in plasma osmolality levels from 0 to 8 ppt (266.63 ± 13.26 mOsm) but plasma osmolality steadily increased at levels above 9 ppt (Figure 18). Mortality for the acclimated trial first occurred at 11 ppt, and 100% mortality occurred at 14 ppt. There was no difference between the plasma osmolality levels of paddlefish exposed to the acclimated and non-acclimated trials (Figure 18).

Lake sturgeon exposed to 0 or 4 ppt for 24 hours without an acclimation period had lower plasma osmolality levels (237.8 ± 3.1 mOsm) compared to lake sturgeon exposed to 12 ppt (322.7 ± 4.5 mOsm) for 24 hours (Figure 19). No mortalities occurred below 16 ppt, and 100% mortality occurred at 16 ppt (Figure 17). Lake sturgeon exposed to an increase of one ppt per day had a slight day to day variation

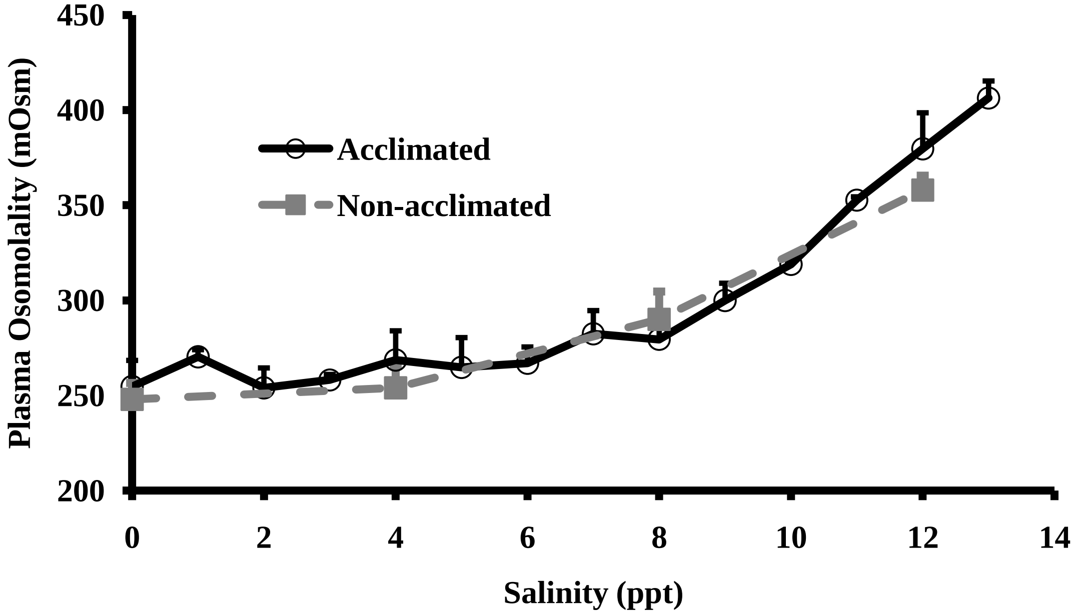

Figure 18. Mean (±SD) plasma osmolality of acclimated and non-acclimated paddlefish exposed to salinity levels for 24 hours. Open circles represent acclimated plasma osmolality, and closed squares represent non-acclimated plasma osmolality.

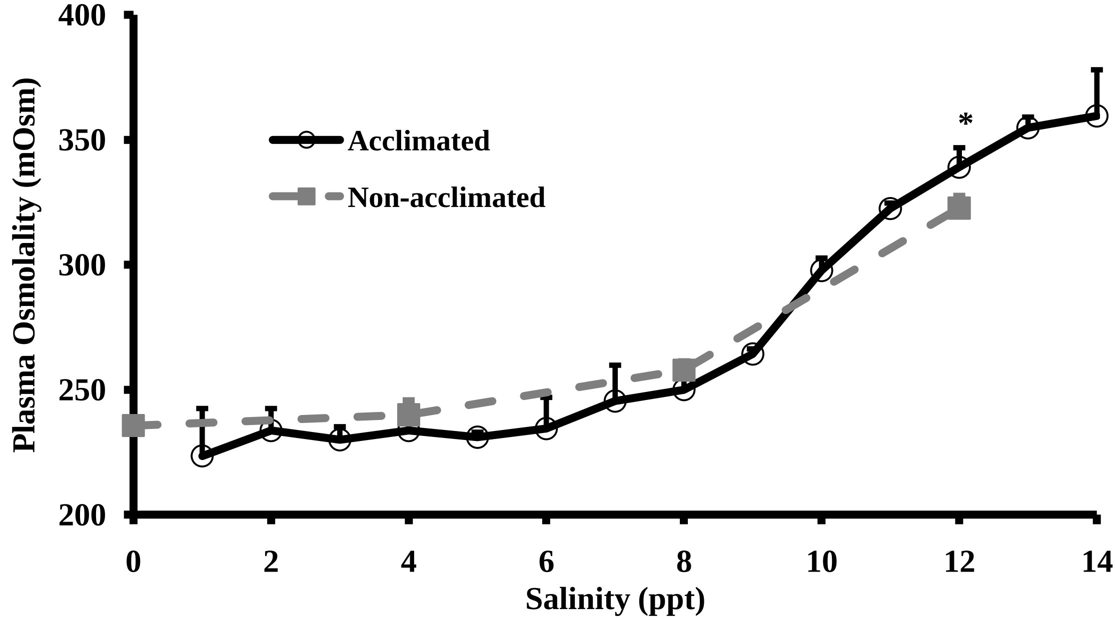

Figure 19. Mean (±SD) plasma osmolality of acclimated, and non-acclimated lake sturgeon exposed to salinity levels for 24 hours. Open circles represent acclimated plasma osmolality, and closed squares represent non-acclimated plasma osmolality. Means with an asterisk indicate a difference between trials.

in plasma osmolality levels from 1 to 6 ppt (231.06 ± 9.5 mOsm) but plasma osmolality steadily increased at levels above 7 ppt (Figure 19). Seven mortalities occurred during the acclimated trial, the first mortality occurred at 2 ppt. There was no difference between the plasma osmolality levels of lake sturgeon exposed to the acclimated and non-acclimated trials below 12 ppt (Figure 19).

Spotted gar exposed to 4 or 8 ppt for 24 hours without an acclimation period had lower plasma osmolality levels (257.6 ± 3.1 mOsm) than spotted gar exposed to 16 ppt (408.3 ± 14.5 mOsm) for 24 hours (Figure 20). No mortalities occurred below 16 ppt, 33% mortality occurred at 16 ppt, and 100% mortality occurred at 20 ppt (Figure 17). Spotted gar exposed to an increase of one ppt per day had slight day to day variation in plasma osmolality levels from 0 to 8 ppt (292.48 ± 4.5 mOsm) but plasma osmolality steadily increased at levels above 9 ppt (Figure 20). No mortalities occurred during the acclimated trial. Plasma osmolality was lower at 8 ppt for the non-acclimated trial compared to the acclimated trial (Figure 20).

Acute effects of a lethal dose of salinity on plasma osmolality

Plasma osmolality of juvenile alligator gar exposed to 34.3 ppt salinity without an acclimation period increased over time (Figure 21; $P<0.0001$, $R^2=0.8988$). The plasma osmolality of juvenile alligator gar at the beginning of the trial was 313.6 ± 1.0 mOsm and was 492.2 ± 12.6 mOsm at the end of the trial. Mortality first occurred after 180 minutes.

Plasma osmolality of spotted gar exposed to 24.0 ppt salinity without an acclimation period increased over time (Figure 22; $P<0.0001$, $R^2=0.9012$).

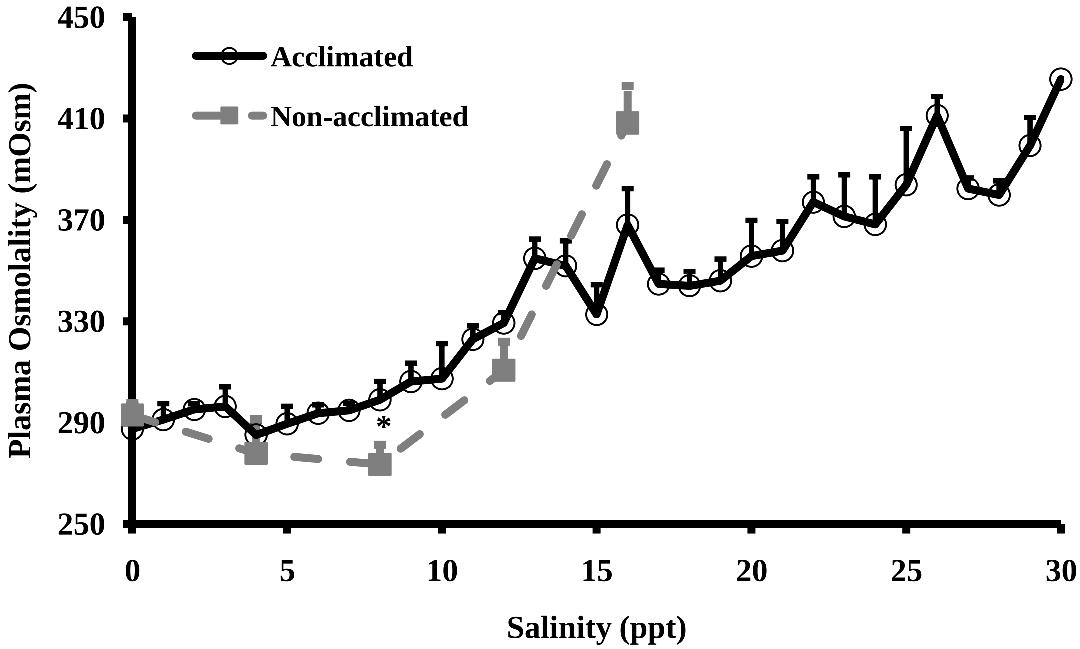

Figure 20. Mean (±SD) plasma osmolality of acclimated, and non-acclimated spotted gar exposed to salinity levels for 24 hours. Open circles represent acclimated plasma osmolality, and closed squares represent non-acclimated plasma osmolality. Means with an asterisk indicate a difference between trials.

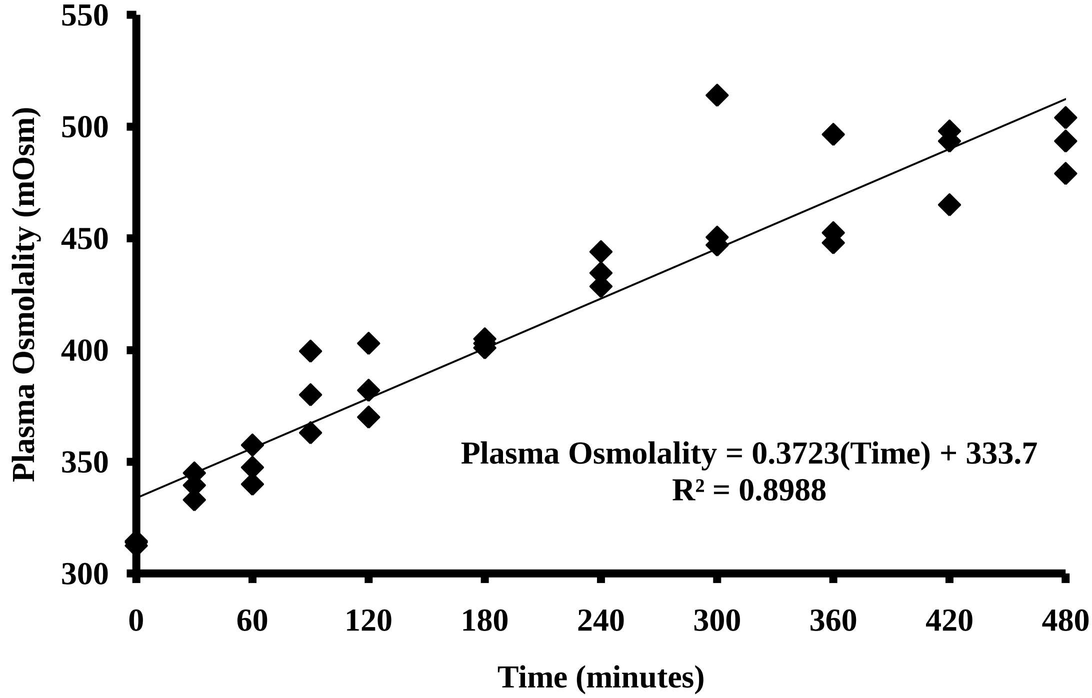

Figure 21. Relationship between plasma osmolality and time for alligator gar introduced to 34.3 ppt salinity (n=3 per time period) without an acclimation period, until 100% mortality occurred.

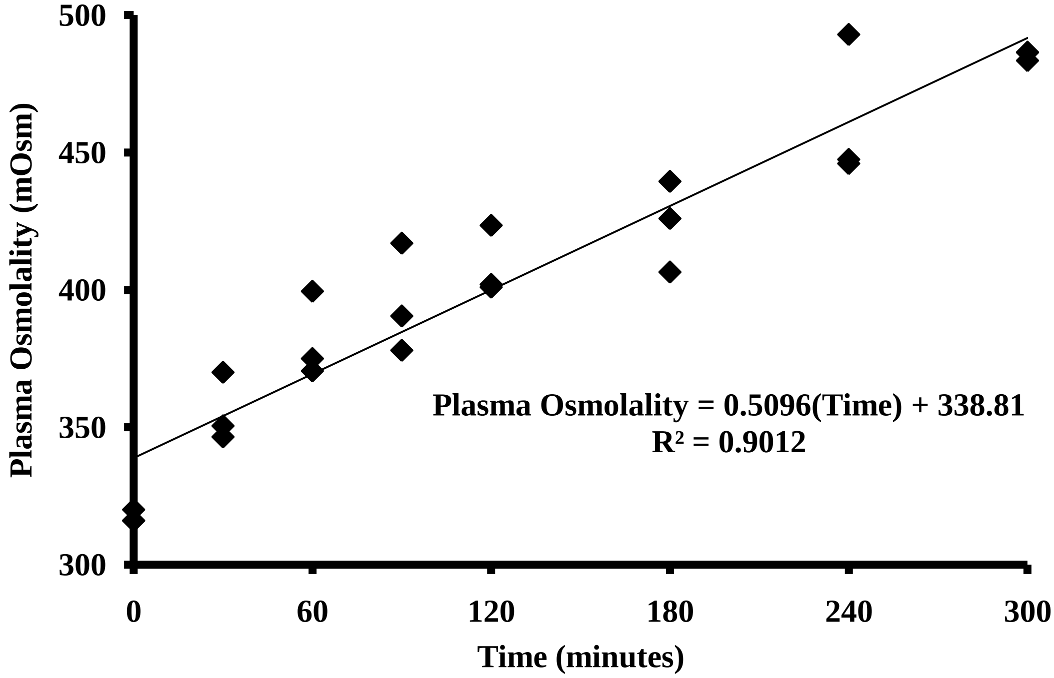

Figure 22. Relationship between plasma osmolality and time for spotted gar introduced to 24.0 ppt salinity (n=3 per time period) without an acclimation period, until 100% mortality occurred. Data collected only for 2 individuals at 120 minutes and 240 minutes.

Spotted gar plasma osmolality level at the beginning of the trial was 317.3 ± 2.3 mOsm and was 485.5 ± 1.7 mOsm at the end of the trial. Mortality first occurred after 90 minutes.

Plasma osmolality of paddlefish exposed to 14.2 ppt salinity without an acclimation period increased over time (Figure 23; $P<0.0001$, $R^2=0.5665$). Paddlefish plasma osmolality level at the beginning of the trial was 264.5 ± 3.1 mOsm and was 322.8 ± 10.3 mOsm at the end of the trial. Mortality first occurred after 180 minutes.

Plasma osmolality of lake sturgeon exposed to 16.2 ppt salinity without an acclimation period had increased over time (Figure 24; $P<0.0001$, $R^2=0.843$). Lake sturgeon plasma osmolality level at the beginning of the trial was 245.5 ± 6.5 mOsm and was 313 mOsm (N=1) at the end of the trial. Mortality first occurred after 120 minutes.

<u>96-hr salinity median-lethal concentration (LC50)</u>

The 96-hour LC50 of small juvenile alligator gar (5.31 ± 0 .55 g; 109.33 ± 3.31 mm) exposed to 12, 16, 18, 19, 20, and 24 ppt was 19.39 ± 1.29 ppt (Table 6). No mortalities occurred at 12, 18, or 19 ppt salinity treatments, 33% mortality occurred at the 16 ppt salinity treatment, and 100% mortality occurred at the 20 and 24 ppt salinity treatment. For the small juvenile alligator gar LC50 trial nitrite-N was 0.008 ± 0.06 mg/L, TAN was 0.97 ± 0.41 mg/L, pH was 8.06 ± 0.05, DO was 5.81 ± 0.43, and temperature was 23.48 ± 1.06 °C (Table 7).

The 96 hour LC50 of large juvenile alligator gar (20.08 ± 2.26 g; 170.21 ± 6.61 mm) exposed to 12, 16, 20, 24, 28, and 32 ppt was 23.33 ± 2.07 ppt (Table 6).

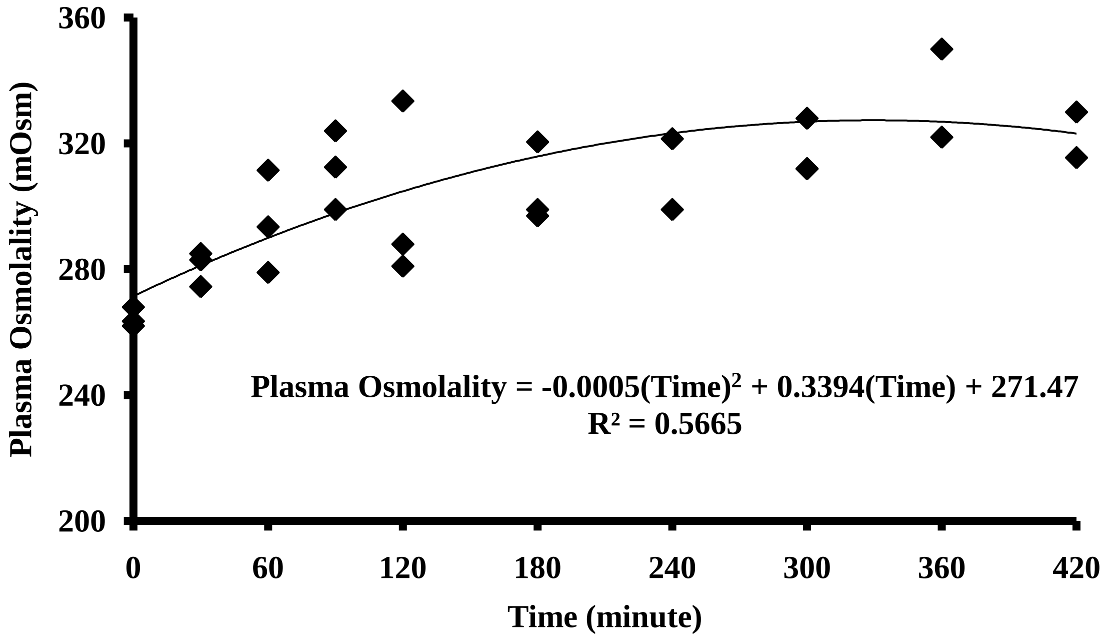

Figure 23. Relationship between plasma osmolality and time for paddlefish introduced to 14.2 ppt salinity (n=3 per time period) without an acclimation period, until 100% mortality occurred. Data collected only for 2 individuals at 240 minutes, 300 minutes, 360 minutes, and 420 minutes.

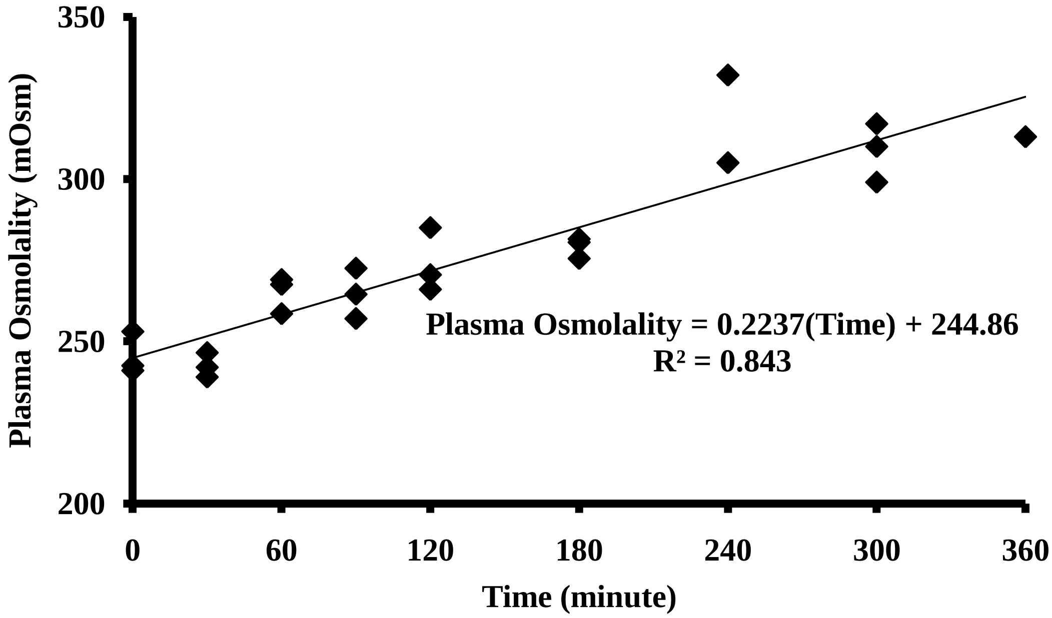

Figure 24. Relationship between plasma osmolality and time for lake sturgeon introduced to 16.2 ppt salinity (n=3 per time period) without an acclimation period, until 100% mortality occurred. Data collected for only 2 individuals at 180 minutes and 240 minutes, and for 1 individual at 360 minutes.

Table 6. Mean (±SD) weight (g), length (mm), and 96-hr LC50 (ppt) of juvenile alligator gar exposed to salinity levels without an acclimation period.

	Weight	**Length**	**LC50**
Small alligator gar	5.31 ± 0.55	109.33 ± 3.31	19.39 ± 1.29
Large alligator gar	20.08 ± 2.26	170.21 ± 6.61	23.33 ± 2.07

Table 7. Mean (±SD) nitrite-N (mg/L), TAN (mg/L), pH, DO (mg/L), and temperature (°C) for juvenile alligator gar 96-hr LC50 trials.

	Nitrite-N	**TAN**	**pH**	**DO**	**Temp**
Small alligator gar	0.008 ± 0.06	0.97 ± 0.41	8.06 ± 0.05	5.81 ± 0.4	23.48 ± 1.1
Large alligator gar	0.07 ± 0.02	0.83 ± 0.73	8.18 ± 0.11	7.48 ± 0.5	23.5 ± 1.2

No mortalities occurred at 12, 16, or 20 ppt salinity treatments, 66% mortality occurred in the 24 ppt treatment, and 100% mortality occurred in the 28 and 32 ppt treatments. For the large juvenile alligator gar LC50 trial nitrite-N was 0.07 ± 0.02 (mg/L), TAN was 0.83 ± 0.73 (mg/L), pH was 8.18±0.11, DO was 7.48 ± 0.49 (mg/L), and temperature was 23.5 ± 1.21 °C (Table 7).

DISSCUSION

Lepisostids are among the oldest living bony fish and are common within the lower Mississippi River system. Although alligator gar populations have declined throughout their range, a robust population of alligator gar occurs along the coast of Louisiana, where salinities can approach full strength sea water (Ferrara 2001; Aguilera et al. 2002; Mendoza et al. 2002a; 2002b; DiBenedetto 2009). Loss of suitable spawning habitat has been attributed to the decline of alligator gar populations throughout their range (Ferrara 2001). Even though alligator gar are a freshwater species, it is possible that the south Louisiana population uses brackish water marshes for spawning. However, high salinity may limit the amount of spawning habitat available to alligator gar in Louisiana's brackish marshes.

Fishes usually have a range of requirements (i.e., temperature, DO, salinity) for a successful spawn, and if one variable is not within acceptable limits, reproduction may not be successful (Barnard and McBain 1994; Wedemeyer 2001). Based on the results of my study, growth and survival of yolk-sac alligator gar are not affected at salinities up to 6 ppt, but growth and survival significantly decrease at 8 ppt and above. Blacknose silverside and pike silverside, *Chrostoma estor estor* can tolerate salinity up to 5 ppt but growth and survival are reduced at salinities of 10 ppt and above (Martinez-Palacios et al. 2004; Martinez-Palacios et al. 2008). Apparently, alligator gar can effectively use Louisiana coastal marshes for spawning habitat, as long as salinity is 6 ppt or lower. If alligator gar spawn in salinities near 8 ppt, larval survival and growth may be negatively impacted.

Alligator gar and other species living in Louisiana's estuaries may experience changes in salinity due to the dynamic nature of estuaries (Moyle and Cech 1988). Changes in salinity may be rapid or slow and affect species differently depending on the amount and rate of change experienced (Martinez-Palacios et al. 2004; Martinez-Palacios et al. 2008). Salinity may vary at a location within the estuary, and variation in salinity may be experienced due to movement of a species within the estuary (Moyle and Cech 1988). The salinity tolerance of a species may be affected by the variation in salinity experienced throughout the life cycle (Neill and Bryan 1991).

Salinity tolerance is species specific and often increases with age (Conte and Wagner 1965; Parry 1960; Stickney 1991; Altinok et al. 1998). It appears that salinity tolerance for juvenile alligator gar is more dependent on size than on age based on my 96-hr LC50 study. However, these results are somewhat ambiguous when compared to the results of the growth studies. Because salinity tolerance increases with increased size, I expected to see higher growth rates at higher salinity in larger fish; however the opposite was observed. One possible explanation is the higher temperatures experienced by the older individuals may have increased standard metabolic rate, thus requiring more energy for osmoregulation (Hattingh et al 1975; Neill and Bryan 1991). Based on the results of the 96-hr LC50 and effect of salinity on growth experiments, juvenile alligator gar size needs to be considered when stocking into salinity. Using these parameters, survival rates of stocked fish should be maximized, with little osmoregulatory demands on the fish.

Growth in some fish species can be optimized when cultured at a salinity that minimizes osmoregulatory demands, and increase the amount of energy available for growth (Iwama 1996; Boeuf and Payan 2001). Most fish species have faster growth rates between 5 and 18 ppt compared to freshwater (Boeuf and Payan 2001). Optimal salinity for juvenile alligator gar is somewhere between 0 and 8 ppt based on the growth trial results. Salinity can also affect SGR and FCR of fish species (Altinok and Grizzle 2001). The SGR of juvenile alligator gar SGR was not affected by salinity; however, FCR was lowest at 0 ppt. Altinok and Grizzle (2001) found that three freshwater euryhaline species had better SGR, and FCR at 3 or 9 ppt compared to 0 or 1 ppt, which contradicts my results. By rearing juvenile alligator gar in the optimal salinity growth, SGR, and FCR levels can be maximized. This may increase production efficiency, and increase the efficiency of stocking efforts.

Alligator gar stocking programs have been conducted by the Mississippi Wildlife, Fisheries, and Park, the Kentucky Department of Fish and Wildlife Resources, the Tennessee Wildlife Resource Agency, and the Alabama Department of Conservation and Natural Resource in cooperation with the Private John Allen National Fish Hatchery (Tupelo, Mississippi; personal communication, Ricky Campbell, Private John Allen National Fish Hatchery, Tupelo, Mississippi). However, no restocking efforts have been conducted in brackish waters. Based on the results of the salinity acclimation trials, juvenile alligator gar without an acclimation period, have the ability to tolerate a change in salinity from 0 to 16 ppt, without compromising plasma osmolality. Furthermore, if a slow change in salinity occurs (1 ppt/day) juvenile alligator gar can tolerate salinities up to 28 ppt, before a change in plasma osmolality occurs. Therefore, if juvenile alligator gar are to be stocked into areas with salinity levels > 16 ppt the fish should be acclimated to the target salinity prior to stocking.

Salinity can be used to decrease transportation mortality of freshwater fish by reducing osmoregulatory demands (Hattingh et al. 1975; Urbinate and Carneiro 2006). Concentrations of 3 – 7 ppt are used for transportation of freshwater fish; however salinity levels are species specific (Hattingh et al. 1975; Urbinate and Carneiro 2006). Alligator gar should be transported to stocking sites at 10 ppt, the salinity other researchers have suggested reduces osmoregulatory demands for many fish species (Rao 1968; Boeuf and Payan 2001). Alligator gar can tolerate a lethal salinity level (34 ppt) without an acclimation period for up to 180 minutes before mortality occurs. This ability to tolerate up to 34 ppt allows culturist to use high-salinity baths for a short period (30-90 minutes) to combat fungal, copepod, or trematode outbreaks, making production and restocking programs more efficient and reducing disease (Piper et al. 1986; Stoskopf 1993).

In 2009 spotted gar were stocked in Port Sulphur, Louisiana, in an effort to control tilapia, *Oreochromis* spp. that escaped from a private lake. Spotted gar (average length 45.7 cm) were collected from the Atchafalaya River Basin, Louisiana, and transported to Port Sulphur, for stocking into salinities ranging from 2.5 - 3.2 ppt (personal communication, Melissa Kaintz, Louisiana Department of Wildlife and Fisheries). Based on the results of the salinity acclimation trials, spotted gar without an acclimation period can tolerate salinities up to 12 ppt before compromising plasma osmolality. Spotted gar should be transported at 6 ppt to decrease osmoregulatory demands, which is a similar to recommendations of Urbinate and Carneiro (2006) for the transportation of *Brycon amazonicus*. Spotted gar exposed to a lethal salinity level (24.0 ppt) can survive for up to 90 minutes before mortality occurs. Similar to the alligator gar, spotted gar can tolerate up to 24 ppt, which allows culturists to use high-salinity baths for a short period (30-90 minutes) to prevent fungal, copepod, or trematode outbreaks (Piper et al. 1986; Stoskopf 1993). High salinity baths may also be used to remove infections on wild caught fish, removing the necessity for a wild caught isolation tank.

Ten states stock paddlefish to restore populations that declined because of habitat loss, poaching, past overfishing, and pollution (Graham 1997). The use of salinity during the transport of paddlefish can decrease osmoregulatory demands, and possibly decrease mortality during transportation (Hattingh et al. 1975). Paddlefish have a very low salinity tolerance, and salinity affects them the same either with or without an acclimation period. Paddlefish tolerate a change in salinity from 0 to 4 ppt before plasma osmolality is affected. Paddlefish should be transported at salinities between 3 – 4 ppt, which is similar to recommendations by Hattingh et al. (1975) for other freshwater fish species. Paddlefish exposed to a lethal salinity level (14.2 ppt) survived for 90 minutes before mortality occurred. Paddlefish can tolerate 14.2 ppt for a short time (< 2 hours), this salinity maybe too low and for too short of a period to effectively treat external parasites; however, a lower salinity treatment for a longer period can be affectively used to treat external parasites. This is supported by Mims (2001) who suggests a salinity treatment of 3 ppt for several days, to eliminate Ick, *Ichthyophthirius multifiliis*, and possible other pathogens.

Lake sturgeon populations have declined across much of their range because of overharvesting, habitat destruction and construction of dams (Hay-Chmielewskit and Whelan 1997). Because of a decline in populations, lake sturgeon restocking efforts have been pursued by many states (personal communication, Ricky Campbell, Private John

Allen National Fish Hatchery, Tupelo, Mississippi). Similar to the paddlefish, lake sturgeon have a very low salinity tolerance and salinity affects lake sturgeon the same either with or without an acclimation period. Lake sturgeon should be transported between 3 – 4 ppt, similar to what Aloisi et al. (2006) suggests. Lake sturgeon exposed to a lethal salinity level (16.2 ppt) survived for 120 minutes before the first mortality occurred. Although lake sturgeon can tolerate 16.2 ppt for a short period, a salinity treatment similar to what Mims (2001) suggested for paddlefish might be sufficient to control certain pathogenic outbreaks.

The use of Louisiana's estuaries by alligator gar and spotted gar has been documented, and helps to explain the tolerance of relatively high salinity (Smith 2008; DiBenedetto 2009). The lack of tolerance to moderate salinity levels of lake sturgeon and paddlefish is reasonable because they are rarely found in saline areas (Ross 2001). The results from all species exposed to the salinity acclimation trials will be useful to fish culturist and biologists giving species specific salinity ranges that may increase production and stocking efficiency by decreasing mortality levels.

Although gar culture is in its infancy in the United States, the ability of alligator gar to tolerate various water quality conditions and having fast growth rates make alligator gar desirable candidates for further studies. In order for consumers to demand alligator gar meat, a market needs to be established. In regions where gar is consumed (i.e. Louisiana, and Texas) it will not be hard to establish a market; however, other regions may take more time for consumer education before a market is created. An aquaculture based market for alligator gar may help relieve commercial and recreational fishing pressure on natural populations. If fishing pressure is reduced it may allow present populations to increase. Besides relieving pressure on natural populations, reared fish can be released to replenish natural populations.

RECOMMENDATIONS

The culture of alligator gar is needed to replenish depleted natural population. To increase the production efficiency of alligator gar culture juveniles should be reared between 0 and 8 ppt. Further research is needed to identify the optimal salinity level in which growth rates will be the greatest. Furthermore, alligator gar size needs to be considered when stocking in areas of salinity. When transporting alligator gar, the water should be 10 ppt to decrease osmoregulatory demands. If juvenile alligator gar are stocked in a salinity > 16 ppt, the fish must be acclimated to the salinity into which they will be introduced, fish stocked in areas < 16 ppt do not need an acclimation period.

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Appendix I- Salinity (ppt), replicate, length (mm), weight (g), and survival (yes/Y; no/N) of yolk-sac alligator gar exposed to salinity for five days.

Salinity	Replicate	Length	Weight	Survival
0	1	16.1	0.00476	Y
0	1	15.4	0.00476	Y
0	1	15.1	0.00476	Y
0	1	15.2	0.00476	Y
0	1	17.2	0.00476	Y
0	2	15.6	0.00472	Y
0	2	16.1	0.00472	Y
0	2	15.6	0.00472	Y
0	2	14.6	0.00472	Y
0	2	17.1	0.00472	Y
0	3	15.6	0.00476	Y
0	3	16.8	0.00476	Y
0	3	16.7	0.00476	Y
0	3	16.4	0.00476	Y
0	3	17.8	0.00476	Y
2	1	12.2	0.00482	Y
2	1	15.2	0.00482	Y
2	1	16.2	0.00482	Y
2	1	16.3	0.00482	Y
2	1	16.2	0.00482	Y
2	2	15.3	0.0047	Y
2	2	16	0.0047	Y
2	2	14.7	0.0047	Y
2	2	15.4	0.0047	Y
2	2	16.2	0.0047	Y
2	3	13.7	0.00472	Y
2	3	16.2	0.00472	Y
2	3	15.3	0.00472	Y
2	3	16	0.00472	Y
2	3	15.4	0.00472	Y
4	1	15.5	0.00494	Y
4	1	16.5	0.00494	Y
4	1	14.1	0.00494	Y
4	1	13.7	0.00494	Y
4	1	15.6	0.00494	Y
4	2	15.3	0.00478	Y
4	2	13.8	0.00478	Y
4	2	13.4	0.00478	Y
4	2	15	0.00478	Y
4	2	16.4	0.00478	Y

Salinity	Replicate	Length	Weight	Survival
4	3	14.8	0.00488	Y
4	3	15.6	0.00488	Y
4	3	14.2	0.00488	Y
4	3	13.3	0.00488	Y
4	3	14	0.00488	Y
6	1	15.8	0.00478	Y
6	1	16.1	0.00478	Y
6	1	14.1	0.00478	Y
6	1	15.2	0.00478	Y
6	1	16.2	0.00478	Y
6	2	16.1	0.00486	Y
6	2	16.3	0.00486	Y
6	2	15.9	0.00486	Y
6	2	15.5	0.00486	Y
6	2	15.9	0.00486	N
6	3	15.8	0.00484	N
6	3	16.1	0.00484	N
6	3	14.1	0.00484	N
6	3	15.2	0.00484	N
6	3	16.2	0.00484	N
8	1	11.8	0.004925	N
8	1	12.4	0.004925	N
8	1	11.3	0.004925	N
8	1	12.6	0.004925	N
8	1	12.7	0.0045	N
8	2	14.5	0.0042	N
8	2	12.7	0.0049	N
8	2	12.1	0.0049	N
8	2	10.9	0.0049	N
8	2	12	0.0049	N
8	3	9.3	0.0047	N
8	3	11.6	0.005275	N
8	3	12.4	0.005275	N
8	3	12	0.005275	N
8	3	11.9	0.005275	N
10	1	10.4	0.00512	N
10	1	9.9	0.00512	N
10	1	10	0.00512	N
10	1	9.4	0.00512	N

Salinity	Replicate	Length	Weight	Survival
10	1	9.8	0.00512	N
10	2	10.2	0.0031	N
10	2	10.7	0.0031	N
10	2	10	0.0031	N
10	2	10.9	0.0031	N
10	2	10.5	0.0032	N
10	3	9.7	0.00506	N
10	3	9.7	0.00506	N
10	3	10.1	0.00506	N
10	3	10.5	0.00506	N
10	3	10.8	0.00506	N
12	1	8.7	0.00502	N
12	1	10	0.00502	N
12	1	10.2	0.00502	N
12	1	10.3	0.00502	N
12	1	9.9	0.00502	N
12	2	10.5	0.00506	N
12	2	10.2	0.00506	N
12	2	10.4	0.00506	N
12	2	9.1	0.00506	N
12	2	9.7	0.00506	N
12	3	10.5	0.00502	N
12	3	10.2	0.00502	N
12	3	10.7	0.00502	N
12	3	10.3	0.00502	N
12	3	10.6	0.00502	N
14	1	9.7	0.004767	N
14	1	9.5	0.004767	N
14	1	9.7	0.004767	N
14	1	9.7	0.0051	N
14	1	8.8	0.0045	N
14	2	10.3	0.0051	N
14	2	9.1	0.0051	N
14	2	9.3	0.0051	N
14	2	9.9	0.0051	N
14	2	9.4	0.0051	N
14	3	9.6	0.0046	N
14	3	10.5	0.0043	N
14	3	10.1	0.0051	N
14	3	8.9	0.0051	N
14	3	9.7	0.0051	N

Appendix II- Day after hatch (DAH), salinity (ppt), replicate, and weight (g) of juvenile alligator gar 20- 51 DAH exposed to a 31 day growth trial conducted at 0, 4, 8 or 12 ppt.

DAH	Salinity	Replicate	Weight
19	0	1	0.0885
19	0	2	0.0885
19	0	3	0.0885
19	4	1	0.0891
19	4	2	0.0891
19	4	3	0.0891
19	8	1	0.085
19	8	2	0.085
19	8	3	0.085
19	12	1	0.0786
19	12	2	0.0786
19	12	3	0.0786
25	0	1	0.2259
25	0	2	0.2545
25	0	3	0.243
25	4	1	0.2794
25	4	2	0.2488
25	4	3	0.2784
25	8	1	0.2625
25	8	2	0.2012
25	8	3	0.2517
25	12	1	0.13
25	12	2	0.2129
25	12	3	0.2733
29	0	1	0.458
29	0	2	0.4806
29	0	3	0.4733
29	4	1	0.7022
29	4	2	0.5568
29	4	3	0.4458
29	8	1	0.4816
29	8	2	0.6179
29	8	3	0.473
29	12	1	0.555
29	12	2	0.4831
29	12	3	0.546
32	0	1	0.74
32	0	2	0.755
32	0	3	0.73

DAH	Salinity	Replicate	Weight
32	4	1	0.9
32	4	2	0.745
32	4	3	0.79
32	8	1	0.725
32	8	2	0.755
32	8	3	0.745
32	12	1	0.65
32	12	2	0.715
32	12	3	0.61
36	0	1	1.16
36	0	2	1.39
36	0	3	1.22
36	4	1	1.875
36	4	2	1.71
36	4	3	1.505
36	8	1	1.535
36	8	2	1.595
36	8	3	1.47
36	12	1	1.185
36	12	2	1.255
36	12	3	0.98
40	0	1	1.0155
40	0	2	1.66
40	0	3	1.8725
40	4	1	2.4565
40	4	2	2.113
40	4	3	1.98
40	8	1	1.9765
40	8	2	2.135
40	8	3	2.2725
40	12	1	2.337
40	12	2	1.9985
40	12	3	1.5725
44	0	1	2.327
44	0	2	2.865
44	0	3	2.9125
44	4	1	3.275
44	4	2	3.36
44	4	3	2.9725

DAH	Salinity	Replicate	Weight
44	8	1	3.029
44	8	2	3.7405
44	8	3	3.0665
44	12	1	3.1875
44	12	2	2.9775
44	12	3	2.715
48	0	1	3.01
48	0	2	3.825
48	0	3	3.975
48	4	1	5.605
48	4	2	4.975
48	4	3	4.12
48	8	1	4.7075
48	8	2	5.945
48	8	3	4.64
48	12	1	4.6245
48	12	2	4.525
48	12	3	3.875
51	0	1	5.482979
51	0	2	4.341609
51	0	3	5.5475
51	4	1	5.4262
51	4	2	8.177128
51	4	3	7.267791
51	8	1	5.308686
51	8	2	6.729767
51	8	3	7.773077
51	12	1	6.779875
51	12	2	5.946923
51	12	3	5.973824

Appendix III- Day after hatch (DAH), salinity (ppt), replicate, and weight (g) of juvenile alligator gar 50- 77 DAH exposed to a 28 day growth trial conducted at 0, 8, 12 or 18 ppt.

DAH	Salinity	Replicate	Weight
50	0	1	8.7687
50	0	2	8.9643
50	0	3	8.9357
50	6	1	8.881
50	6	2	8.4237
50	6	3	8.764
50	12	1	8.8427
50	12	2	8.4117
50	12	3	8.5757
50	18	1	8.294
50	18	2	8.588
50	18	3	8.8497
52	0	1	10.814
52	0	2	11.315
52	0	3	11.243
52	6	1	11.535
52	6	2	11.209
52	6	3	11.644
52	12	1	10.975
52	12	2	11.295
52	12	3	11.892
52	18	1	11.305
52	18	2	11.083
52	18	3	12.346
54	0	1	14.011
54	0	2	14.605
54	0	3	15.1
54	6	1	15.047
54	6	2	15.082
54	6	3	14.098
54	12	1	13.283
54	12	2	15.238
54	12	3	14.218
54	18	1	14.069
54	18	2	13.367
54	18	3	14.496
56	0	1	17.855
56	0	2	19.051

DAH	Salinity	Replicate	Weight
56	0	3	20.001
56	6	1	19.063
56	6	2	19.536
56	6	3	20.373
56	12	1	18.062
56	12	2	18.907
56	12	3	17.771
56	18	1	16.338
56	18	2	16.822
56	18	3	18.135
58	0	1	23.553
58	0	2	23.732
58	0	3	24.819
58	6	1	23.521
58	6	2	22.959
58	6	3	26.207
58	12	1	23.014
58	12	2	21.969
58	12	3	23.039
58	18	1	18.567
58	18	2	20.548
58	18	3	22.072
60	0	1	28.2248
60	0	2	29.395
60	0	3	32.302
60	6	1	26.09
60	6	2	26.891
60	6	3	30.635
60	12	1	25.868
60	12	2	27.631
60	12	3	25.072
60	18	1	24.223
60	18	2	26.734
60	18	3	26.199
62	0	1	35.435
62	0	2	37.195
62	0	3	37.727
62	6	1	28.59
62	6	2	31.911

DAH	Salinity	Replicate	Weight
62	6	3	36.084
62	12	1	31.559
62	12	2	31.012
62	12	3	30.863
62	18	1	30.01
62	18	2	31.093
62	18	3	30.227
64	0	1	37.367
64	0	2	37.985
64	0	3	39.829
64	6	1	32.8
64	6	2	35.553
64	6	3	38.863
64	12	1	33.249
64	12	2	35.892
64	12	3	28.3729
64	18	1	31.852
64	18	2	35.167
64	18	3	33.415
66	0	1	40.78
66	0	2	45.843
66	0	3	47.072
66	6	1	37.388
66	6	2	41.424
66	6	3	44.709
66	12	1	38.133
66	12	2	41.316
66	12	3	33.931
66	18	1	36.221
66	18	2	42.282
66	18	3	37.398
68	0	1	49.56
68	0	2	51.516
68	0	3	50.911
68	6	1	43.741
68	6	2	46.706
68	6	3	49.418
68	12	1	47.184
68	12	2	43.531

DAH	Salinity	Replicate	Weight
68	12	3	38.168
68	18	1	41.883
68	18	2	42.5
68	18	3	42.016
70	0	1	57.075
70	0	2	55.201
70	0	3	55.335
70	6	1	44.138
70	6	2	47.269
70	6	3	52.512
70	12	1	49.337
70	12	2	48.707
70	12	3	43.585
70	18	1	44.627
70	18	2	48.706
70	18	3	53.057
72	0	1	58.868
72	0	2	61.296
72	0	3	61.826
72	6	1	53.048
72	6	2	54.773
72	6	3	56.529
72	12	1	49.945
72	12	2	56.04
72	12	3	50.395
72	18	1	48.833
72	18	2	58.987
72	18	3	47.639
74	0	1	65.968
74	0	2	66.653
74	0	3	65.735
74	6	1	57.202
74	6	2	55.727
74	6	3	60.797
74	12	1	59.749
74	12	2	56.38
74	12	3	53.88
74	18	1	56.285
74	18	2	61.705

DAH	Salinity	Replicate	Weight
74	18	3	58.743
76	0	1	71.401
76	0	2	71.926
76	0	3	73.377
76	6	1	57.126
76	6	2	65.728
76	6	3	68.86
76	12	1	58.597
76	12	2	68.943
76	12	3	56.134
76	18	1	66.464
76	18	2	66.385
76	18	3	66.558
77	0	1	73.02821
77	0	2	77.96929
77	0	3	77.33567
77	6	1	54.40207
77	6	2	63.82643
77	6	3	69.86621
77	12	1	65.49625
77	12	2	68.5204
77	12	3	49.54267
77	18	1	59.06767
77	18	2	69.5256
77	18	3	66.78393

Appendix IV- Species, salinity (ppt), replicate, length (mm), weight (g), and plasma osmolality (mOsm) of acclimated plasma osmolality trials.

Species	Salinity	Replicate	Length	Weight	Plasma Osmolality
Alligator gar	0	1	193	27.9	306.5
Alligator gar	0	2	211	36.6	305
Alligator gar	0	3	200	30.7	301
Alligator gar	1	1	193	24.1	310.5
Alligator gar	1	2	203	33.1	313.5
Alligator gar	1	3	205	31.2	328.5
Alligator gar	2	1	182	21	300.5
Alligator gar	2	2	192	24.5	298
Alligator gar	2	3	199	30.3	306.5
Alligator gar	3	1	202	29.9	317
Alligator gar	3	2	229	40.7	309
Alligator gar	3	3	191	25.1	309
Alligator gar	4	1	186	18.4	301.5
Alligator gar	4	2	199	28.8	308.5
Alligator gar	4	3	180	20.7	298
Alligator gar	5	1	232	47.9	315
Alligator gar	5	2	220	39	308.5
Alligator gar	5	3	216	31.9	316
Alligator gar	6	1	180	20	309
Alligator gar	6	2	201	29.2	306
Alligator gar	6	3	176	18.8	312
Alligator gar	7	1	245	55	317.5
Alligator gar	7	2	153	11.6	295.5
Alligator gar	7	3	179	20.6	306
Alligator gar	8	1	199	24.4	306.5
Alligator gar	8	2	199	27.3	305
Alligator gar	8	3	193	27.4	304
Alligator gar	9	1	232	42.5	308
Alligator gar	9	2	185	19.2	297.5
Alligator gar	9	3	200	26.2	306
Alligator gar	10	1	202	27.4	307
Alligator gar	10	2	208	32.3	311.5
Alligator gar	10	3	182	20.6	312.5
Alligator gar	11	1	216	34.9	309.5
Alligator gar	11	2	198	26.6	309.5
Alligator gar	11	3	217	35.5	302.5
Alligator gar	12	1	228	44	306
Alligator gar	12	2	202	28.3	307
Alligator gar	12	3	173	18.2	305

Species	Salinity	Replicate	Length	Weight	Plasma Osmolality
Alligator gar	13	1	206	28.1	302.5
Alligator gar	13	2	185	21.1	300
Alligator gar	13	3	196	25.1	303.5
Alligator gar	14	1	204	28.6	304.5
Alligator gar	14	2	205	33.3	306
Alligator gar	14	3	179	19.2	303
Alligator gar	15	1	210	28.5	297
Alligator gar	15	2	200	23.8	293
Alligator gar	15	3	201	24.4	293
Alligator gar	16	1	185	19.1	297
Alligator gar	16	2	203	24.9	284.5
Alligator gar	16	3	226	40.6	297
Alligator gar	17	1	213	33.5	308.5
Alligator gar	17	2	215	32.8	311.5
Alligator gar	17	3	217	34.1	292
Alligator gar	18	1	196	21.2	290.5
Alligator gar	18	2	188	21.5	310.5
Alligator gar	18	3	193	23	304
Alligator gar	19	1	216	33.2	339
Alligator gar	19	2	214	31.8	317.5
Alligator gar	19	3	223	38	318
Alligator gar	20	1	198	25.4	323
Alligator gar	20	2	203	26.2	318
Alligator gar	20	3	170	14.2	302
Alligator gar	21	1	182	18.2	313
Alligator gar	21	2	190	22.2	301
Alligator gar	21	3	197	24	303.5
Alligator gar	22	1	182	19.6	310
Alligator gar	22	2	199	24.6	309
Alligator gar	22	3	202	26.1	298
Alligator gar	23	1	205	28.6	310
Alligator gar	23	2	207	29.6	303
Alligator gar	23	3	215	34.1	309
Alligator gar	24	1	200	26.3	317.5
Alligator gar	24	2	198	24.8	330
Alligator gar	24	3	193	23.3	311.5
Alligator gar	25	1	187	19.6	306
Alligator gar	25	2	197	24.5	319
Alligator gar	25	3	192	20.3	304

Species	Salinity	Replicate	Length	Weight	Plasma Osmolality
Alligator gar	26	1	205	25.7	308.5
Alligator gar	26	2	184	21.3	309.5
Alligator gar	26	3	210	29.6	314
Alligator gar	27	1	199	23.7	303
Alligator gar	27	2	180	17.6	324.5
Alligator gar	27	3	210	28.9	331
Alligator gar	28	1	203	26.4	334.5
Alligator gar	28	2	195	23.8	332.5
Alligator gar	28	3	217	34.1	321
Alligator gar	29	1	231	40.2	321.5
Alligator gar	29	2	209	28.9	319.5
Alligator gar	29	3	216	33.5	318
Alligator gar	30	1	187	21.6	327
Alligator gar	30	2	193	21.7	324
Alligator gar	30	3	211	28.9	333.5
Alligator gar	31	1	225	34.7	321
Alligator gar	31	2	234	41.1	324
Alligator gar	31	3	206	32.5	331
Alligator gar	32	1	210	30.3	346.5
Alligator gar	32	2	221	35.2	347.5
Alligator gar	32	3	236	42.6	340.5
Alligator gar	33	1	245	45	323.5
Alligator gar	33	2	248	51.4	338
Alligator gar	33	3	232	41	337
Alligator gar	34	1	225	37.2	353
Alligator gar	34	2	245	46.2	355
Alligator gar	34	3	236	46.9	351.5
Alligator gar	35	1	244	26	350.5
Alligator gar	35	2	228	39.6	338.5
Alligator gar	35	3	240	46.8	339
Alligator gar	36	1	240	45.9	360
Alligator gar	36	2	223	34.2	351.5
Alligator gar	36	3	247	51.9	332
Alligator gar	37	1	253	52.6	363.5
Alligator gar	37	2	236	43.7	381.5
Alligator gar	37	3	222	36.6	372
Paddlefish	0	1	400	111.5	239.5
Paddlefish	0	2	358	95.5	258
Paddlefish	0	3	440	230	266.5

Species	Salinity	Replicate	Length	Weight	Plasma Osmolality
Paddlefish	1	1	336	66.5	266
Paddlefish	1	2	400	174.5	272.5
Paddlefish	1	3	384	115.5	272.5
Paddlefish	2	1	396	130.5	254
Paddlefish	2	2	417	162	264.5
Paddlefish	2	3	313	86	243.5
Paddlefish	3	1	423	167.5	256
Paddlefish	3	2	428	159	257
Paddlefish	3	3	373	103.5	261.5
Paddlefish	4	1	358	69.5	270.5
Paddlefish	4	2	406	130	252.5
Paddlefish	4	3	350	61	283
Paddlefish	5	1	394	121.5	247
Paddlefish	5	2	350	88.5	276
Paddlefish	5	3	315	67.5	271.5
Paddlefish	6	1	379	109	260
Paddlefish	6	2	415	161	264.5
Paddlefish	6	3	358	101	276.5
Paddlefish	7	1	434	165.5	272.5
Paddlefish	7	2	396	138.5	279
Paddlefish	7	3	437	169.5	296
Paddlefish	8	1	360	91	285.5
Paddlefish	8	2	405	123	280.5
Paddlefish	8	3	363	87	272.5
Paddlefish	9	1	380	92	292.5
Paddlefish	9	2	338	73.5	297.5
Paddlefish	9	3	389	110	310
Paddlefish	10	1	324	62.5	321
Paddlefish	10	2	358	88.5	319
Paddlefish	10	3	418	145.5	317
Paddlefish	11	1	430	188.5	352.5
Paddlefish	11	2	385	104.5	351
Paddlefish	11	3	320	48.5	354.5
Paddlefish	12	1	426	189.5	365
Paddlefish	12	2	411	128	401
Paddlefish	12	3	355	71.5	373
Paddlefish	13	1	395	95.5	396.5
Paddlefish	13	2	340	59	408.5
Paddlefish	13	3	355	72.5	414

Species	Salinity	Replicate	Length	Weight	Plasma Osmolality
Lake sturgeon	1	1	125	4.98	238
Lake sturgeon	1	2	121	4.38	230.5
Lake sturgeon	1	3	105	2.6	202
Lake sturgeon	2	1	111	2.86	226.5
Lake sturgeon	2	2	113	3.65	231
Lake sturgeon	2	3	135	6.14	243.5
Lake sturgeon	3	1	111	3.06	227
Lake sturgeon	3	2	115	3.19	227
Lake sturgeon	3	3	120	3.88	236
Lake sturgeon	4	1	108	2.62	230.5
Lake sturgeon	4	2	105	2.52	232
Lake sturgeon	4	3	115	3.15	238.5
Lake sturgeon	5	1	117	3.65	231
Lake sturgeon	5	2	115	3.35	229
Lake sturgeon	5	3	120	3.71	233
Lake sturgeon	6	1	120	4	237
Lake sturgeon	6	2	125	3.74	221
Lake sturgeon	6	3	130	5.15	245.5
Lake sturgeon	7	1	115	3.75	230.5
Lake sturgeon	7	2	133	4.87	259
Lake sturgeon	7	3	139	5.2	247
Lake sturgeon	8	1	115	2.92	247
Lake sturgeon	8	2	120	3.93	255
Lake sturgeon	8	3	120	3.25	248
Lake sturgeon	9	1	120	3.44	265.5
Lake sturgeon	9	2	114	2.94	262
Lake sturgeon	9	3	117	3.39	265.5
Lake sturgeon	10	1	121	3.56	302.5
Lake sturgeon	10	2	122	3.91	298
Lake sturgeon	10	3	117	3.31	292.5
Lake sturgeon	11	1	123	4.76	321.5
Lake sturgeon	11	2	126	4.36	325
Lake sturgeon	11	3	113	3.3	321
Lake sturgeon	12	1	120	3.55	330
Lake sturgeon	12	2	120	3.92	343
Lake sturgeon	12	3	120	4.13	344
Lake sturgeon	13	1	130	4.92	358
Lake sturgeon	13	2	115	3.41	350
Lake sturgeon	13	3	130	5.15	356.5

Species	Salinity	Replicate	Length	Weight	Plasma Osmolality
Lake sturgeon	14	1	120	4.22	341
Lake sturgeon	14	2	110	2.83	378
Lake sturgeon	14	3	113	3.17	359.5
Spotted gar	0	1	4.54	128	279
Spotted gar	0	2	3.52	116	285.5
Spotted gar	0	3	3.06	112	298
Spotted gar	1	1	3.82	114	297
Spotted gar	1	2	3.31	112	292
Spotted gar	1	3	3.02	114	284.5
Spotted gar	2	1	4.24	129	297.5
Spotted gar	2	2	4.63	131	293
Spotted gar	2	3	3.78	116	295
Spotted gar	3	1	3.59	111	294
Spotted gar	3	2	3.22	120	290
Spotted gar	3	3	4.38	126	305
Spotted gar	4	1	3.86	124	291.5
Spotted gar	4	2	3.79	117	282
Spotted gar	4	3	2.5	106	282
Spotted gar	5	1	4.75	132	293.5
Spotted gar	5	2	3.64	125	281.5
Spotted gar	5	3	4.99	132	293.5
Spotted gar	6	1	5.05	131	296.5
Spotted gar	6	2	2.63	98	294.5
Spotted gar	6	3	3.57	124	290
Spotted gar	7	1	3.58	116	293
Spotted gar	7	2	6.46	142	298
Spotted gar	7	3	3.41	109	293.5
Spotted gar	8	1	3.07	116	291.5
Spotted gar	8	2	4.59	129	306
Spotted gar	8	3	3.24	109	299.5
Spotted gar	9	1	3.99	119	307
Spotted gar	9	2	3.34	118	313
Spotted gar	9	3	2.91	112	298.5
Spotted gar	10	1	3.5	116	304
Spotted gar	10	2	5.48	139	322.5
Spotted gar	10	3	3.02	117	295.5
Spotted gar	11	1	3.76	121	320
Spotted gar	11	2	5.39	137	319.5
Spotted gar	11	3	3.1	118	329

Species	Salinity	Replicate	Length	Weight	Plasma Osmolality
Spotted gar	12	1	6.3	145	333
Spotted gar	12	2	2.74	115	325
Spotted gar	12	3	2.6	116	330
Spotted gar	13	1	3.75	118	348
Spotted gar	13	2	4.45	126	363
Spotted gar	13	3	3.32	116	353.5
Spotted gar	14	1	4.55	127	340.5
Spotted gar	14	2	3.97	122	356.5
Spotted gar	14	3	2.91	106	358.5
Spotted gar	15	1	5.07	127	328
Spotted gar	15	2	6.59	147	324
Spotted gar	15	3	3.43	126	346
Spotted gar	16	1	2.85	108	354.5
Spotted gar	16	2	2.85	110	383
Spotted gar	16	3	3.3	110	366.5
Spotted gar	17	1	3.05	116	351
Spotted gar	17	2	4.09	129	341.5
Spotted gar	17	3	7.1	142	341.5
Spotted gar	18	1	3.93	123	343
Spotted gar	18	2	3.63	119	350
Spotted gar	18	3	3.53	123	339
Spotted gar	19	1	3.31	116	339
Spotted gar	19	2	4.11	121	355.5
Spotted gar	19	3	3.01	113	343.5
Spotted gar	20	1	3.75	120	358
Spotted gar	20	2	3.91	123	340.5
Spotted gar	20	3	3.31	111	368.5
Spotted gar	21	1	2.97	111	371
Spotted gar	21	2	2.6	111	349.5
Spotted gar	21	3	5.09	130	353
Spotted gar	22	1	4.34	128	382.5
Spotted gar	22	2	3.77	115	365.5
Spotted gar	22	3	5.57	137	383
Spotted gar	23	1	6.48	141	389.5
Spotted gar	23	2	4.78	136	357.5
Spotted gar	23	3	2.63	114	367
Spotted gar	24	1	2.65	111	361
Spotted gar	24	2	5.78	138	389.5
Spotted gar	24	3	3.91	125	354

Species	Salinity	Replicate	Length	Weight	Plasma Osmolality
Spotted gar	25	1	6.07	141	358.5
Spotted gar	25	2	2.63	112	400
Spotted gar	25	3	2.8	107	393
Spotted gar	26	1	2.7	112	411.5
Spotted gar	26	2	4.38	128	418.5
Spotted gar	26	3	3.09	115	403.5
Spotted gar	27	1	5.97	142	377.5
Spotted gar	27	2	2.79	108	385
Spotted gar	27	3	3.3	122	384.5
Spotted gar	28	1	4.33	128	374
Spotted gar	28	2	4.3	124	385
Spotted gar	28	3	5.95	131	380.5
Spotted gar	29	1	4.82	133	398
Spotted gar	29	2	3.92	124	389
Spotted gar	29	3	6.53	146	411
Spotted gar	30	1	-	-	-
Spotted gar	30	2	7.35	151	425.5
Spotted gar	30	3	-	-	-

Appendix V - Species, salinity (ppt), replicate, length (mm), weight (g), and plasma osmolality (mOsm) of non-acclimated plasma osmolality trials.

Species	Salinity	Replicate	Length	Weight	Plasma Osmolality
Alligator gar	0	1	150	12	299
Alligator gar	0	2	149	11.5	299
Alligator gar	0	3	186	11.5	316
Alligator gar	4	1	169	16	302
Alligator gar	4	2	158	14.5	311
Alligator gar	4	3	183	27	317
Alligator gar	8	1	176	18	310
Alligator gar	8	2	160	15	316
Alligator gar	8	3	139	11.5	312
Alligator gar	12	1	139	10.5	326
Alligator gar	12	2	169	16.5	328
Alligator gar	12	3	198	26.5	336
Alligator gar	16	1	184	23.5	325
Alligator gar	16	2	163	14.5	-
Alligator gar	16	3	164	16.5	349
Alligator gar	20	1	173	16.5	394
Alligator gar	20	2	144	10.5	400
Alligator gar	20	3	165	15	389
Alligator gar	24	1	139	10.5	442
Alligator gar	24	2	146	12	465
Alligator gar	24	3	133	8	430
Alligator gar	28	1	137	8.5	465
Alligator gar	28	2	146	10	464
Alligator gar	28	3	-	-	-
Alligator gar	32	1	194	25.9	475
Alligator gar	32	2	-	-	-
Alligator gar	32	3	-	-	-
Paddlefish	0	1	372	98.5	238.3
Paddlefish	0	2	364	88.5	255.3
Paddlefish	0	3	353	87.5	249.3
Paddlefish	4	1	361	98	253.3
Paddlefish	4	2	363	92	242.0
Paddlefish	4	3	352	88.5	256.7
Paddlefish	8	1	351	86.5	273.0
Paddlefish	8	2	373	102.5	299.0
Paddlefish	8	3	354	90	297.7
Paddlefish	12	1	372	90	352.3
Paddlefish	12	2	363	89	363.0
Paddlefish	12	3	-	-	-

Species	Salinity	Replicate	Length	Weight	Plasma Osmolality
Lake sturgeon	0	1	100	2.63	233
Lake sturgeon	0	2	113	3.47	236
Lake sturgeon	0	3	122	4.88	238
Lake sturgeon	4	1	133	5.53	244.5
Lake sturgeon	4	2	110	3.74	234
Lake sturgeon	4	3	126	4.55	241.5
Lake sturgeon	8	1	115	4.55	261.5
Lake sturgeon	8	2	116	4.07	256
Lake sturgeon	8	3	133	5.84	256
Lake sturgeon	12	1	138	6.12	322
Lake sturgeon	12	2	110	3.7	327.5
Lake sturgeon	12	3	122	4.5	318.5
Spotted gar	0	1	3.5	117	288.5
Spotted gar	0	2	3.46	117	298
Spotted gar	0	3	5.16	131	292.5
Spotted gar	4	1	3.73	120	288
Spotted gar	4	2	3.78	116	283
Spotted gar	4	3	3.38	114	262.5
Spotted gar	8	1	4.28	125	265.5
Spotted gar	8	2	3.98	119	274
Spotted gar	8	3	4.79	129	281
Spotted gar	12	1	4.01	117	322
Spotted gar	12	2	3.71	113	310.5
Spotted gar	12	3	3.72	120	299.5
Spotted gar	16	1	5.2	125	398
Spotted gar	16	2	-	-	-
Spotted gar	16	3	4.05	120	418.5

Appendix VI. Species, time (minute), replicate, length (mm), weight (g), and plasma osmolality (mOsm) of fish introduced into a lethal salinity to determine the acute affect of salinity on plasma osmolality .

Species	Time	Replicate	Length	Weight	Plasma Osmolality
Alligator gar	0	1	18.29	161	312.5
Alligator gar	0	2	17.96	166	314.5
Alligator gar	0	3	17.52	166	314
Alligator gar	30	1	13.39	149	333
Alligator gar	30	2	16.32	162	345
Alligator gar	30	3	13.8	154	339.5
Alligator gar	60	1	14.39	159	340
Alligator gar	60	2	14.87	158	357.5
Alligator gar	60	3	16.79	169	347.5
Alligator gar	90	1	16.02	163	399.5
Alligator gar	90	2	19.35	175	363
Alligator gar	90	3	14.87	159	380
Alligator gar	120	1	11.88	151	403
Alligator gar	120	2	18.09	170	370
Alligator gar	120	3	15.23	160	382
Alligator gar	180	1	15.84	156	403
Alligator gar	180	2	16.37	167	401
Alligator gar	180	3	10.5	145	405
Alligator gar	240	1	13.69	156	434.5
Alligator gar	240	2	22.65	186	428.5
Alligator gar	240	3	12.61	155	444
Alligator gar	300	1	11.32	146	514
Alligator gar	300	2	15.19	164	450.5
Alligator gar	300	3	17.66	174	447
Alligator gar	360	1	22.32	185	452.5
Alligator gar	360	2	17.63	171	496.5
Alligator gar	360	3	19.57	180	448
Alligator gar	420	1	17.22	174	498
Alligator gar	420	2	13.82	157	465
Alligator gar	420	3	14.82	161	493.5
Alligator gar	480	1	19.14	181	479
Alligator gar	480	2	17.05	174	493.5
Alligator gar	480	3	17.13	176	504
Paddlefish	0	1	152	422	262
Paddlefish	0	2	136	423	268
Paddlefish	0	3	93	380	263.5
Paddlefish	30	1	99	370	274.5
Paddlefish	30	2	116	385	283
Paddlefish	30	3	105	385	285

Species	Time	Replicate	Length	Weight	Plasma Osmolality
Paddlefish	60	1	158	427	293.5
Paddlefish	60	2	76	360	279
Paddlefish	60	3	138.5	413	311.5
Paddlefish	90	1	109	400	312.5
Paddlefish	90	2	171.5	428	324
Paddlefish	90	3	153.5	420	299
Paddlefish	120	1	177.5	443	281
Paddlefish	120	2	98	371	288
Paddlefish	120	3	134.5	423	333.5
Paddlefish	180	1	102.5	397	299
Paddlefish	180	2	165	438	320.5
Paddlefish	180	3	107	410	297
Paddlefish	240	1	115	415	299
Paddlefish	240	2	238.5	475	369.5
Paddlefish	240	3	194.5	465	321.5
Paddlefish	300	1	152.5	436	312
Paddlefish	300	2	133	410	328
Paddlefish	300	3	129	423	312
Paddlefish	360	1	78	375	322
Paddlefish	360	2	73.5	370	350
Paddlefish	360	3	165	450	-
Paddlefish	420	1	146	430	315.5
Paddlefish	420	2	80	379	330
Paddlefish	420	3	96	386	-
Lake Sturgeon	0	1	3.89	115	242.5
Lake Sturgeon	0	2	4.99	123	253
Lake Sturgeon	0	3	4.25	117	241
Lake Sturgeon	30	1	4.26	116	242
Lake Sturgeon	30	2	5.99	134	239
Lake Sturgeon	30	3	4.38	121	246.5
Lake Sturgeon	60	1	5.53	129	269
Lake Sturgeon	60	2	5.45	134	258.5
Lake Sturgeon	60	3	4.9	120	267.5
Lake Sturgeon	90	1	3.05	110	257
Lake Sturgeon	90	2	4.95	128	272.5
Lake Sturgeon	90	3	6.19	140	264.5
Lake Sturgeon	120	1	3.89	115	270.5
Lake Sturgeon	120	2	4.99	123	266
Lake Sturgeon	120	3	4.25	117	285

Species	Time	Replicate	Length	Weight	Plasma Osmolality
Lake Sturgeon	180	1	3.65	116	281.5
Lake Sturgeon	180	2	6.65	140	280.5
Lake Sturgeon	180	3	4.84	127	275.5
Lake Sturgeon	240	1	5.16	135	332
Lake Sturgeon	240	2	5.3	136	305
Lake Sturgeon	240	3	5.94	135	-
Lake Sturgeon	300	1	5.11	130	299
Lake Sturgeon	300	2	4.66	125	310
Lake Sturgeon	300	3	4.23	125	317
Lake Sturgeon	360	1	6.63	143	313
Lake Sturgeon	360	2	4.7	130	-
Lake Sturgeon	360	3	3.4	120	-
Spotted gar	0	1	5.03	131	316
Spotted gar	0	2	5.56	130	320
Spotted gar	0	3	4.43	122	316
Spotted gar	30	1	5.8	130	350.5
Spotted gar	30	2	3.48	116	370
Spotted gar	30	3	3.44	116	346.5
Spotted gar	60	1	4.59	125	370.5
Spotted gar	60	2	3.25	110	375
Spotted gar	60	3	3.36	114	399.5
Spotted gar	90	1	3.46	112	417
Spotted gar	90	2	4.76	129	378
Spotted gar	90	3	3.79	116	390.5
Spotted gar	120	1	4.82	129	402
Spotted gar	120	2	3.84	122	401
Spotted gar	120	3	3.38	115	423.5
Spotted gar	180	1	5.36	126	406.5
Spotted gar	180	2	4.37	119	426
Spotted gar	180	3	3.67	117	439.5
Spotted gar	240	1	5.83	138	447.5
Spotted gar	240	2	3.52	111	493
Spotted gar	240	3	3.48	112	446
Spotted gar	300	1	4.53	126	486.5
Spotted gar	300	2	3.82	120	486.5
Spotted gar	300	3	3.77	119	483.5

Appendix VII. Trial, salinity (ppt), replicate, length (mm), weight (g), and survival (yes/Y; no/N) of alligator gar exposed to salinity to determine 96-hour LC50 concentration.

Trial	Salinity	Replicate	Length	Weight	Survival
Small alligator gar	12	1	5.67	110	Y
Small alligator gar	12	2	5.05	106	Y
Small alligator gar	12	3	6.02	117	Y
Small alligator gar	12	4	5.96	111	Y
Small alligator gar	12	5	5.76	109	Y
Small alligator gar	12	6	5.92	113	N
Small alligator gar	16	1	5.01	103	Y
Small alligator gar	16	2	5.31	106	Y
Small alligator gar	16	3	5.41	108	Y
Small alligator gar	16	4	6.05	112	Y
Small alligator gar	16	5	5.5	107	Y
Small alligator gar	16	6	5.09	108	N
Small alligator gar	18	1	6.33	113	Y
Small alligator gar	18	2	5.18	111	Y
Small alligator gar	18	3	4.67	107	Y
Small alligator gar	18	4	5.29	110	Y
Small alligator gar	18	5	5.69	111	Y
Small alligator gar	18	6	5.04	107	Y
Small alligator gar	19	1	6.27	114	Y
Small alligator gar	19	2	4.72	106	Y
Small alligator gar	19	3	5.95	113	Y
Small alligator gar	19	4	5.2	110	Y
Small alligator gar	19	5	5.45	111	Y
Small alligator gar	19	6	5.91	114	Y
Small alligator gar	20	1	4.8	109	N
Small alligator gar	20	2	4.63	107	N
Small alligator gar	20	3	5.21	111	N
Small alligator gar	20	4	5.01	105	N
Small alligator gar	20	5	5.21	112	N
Small alligator gar	20	6	4.59	107	N
Small alligator gar	24	1	4.04	106	N
Small alligator gar	24	2	5.04	110	N
Small alligator gar	24	3	5.96	115	N
Small alligator gar	24	4	4.83	107	N
Small alligator gar	24	5	4.78	104	N
Small alligator gar	24	6	4.61	106	N
Large alligator gar	12	1	17.18	166	Y
Large alligator gar	12	2	17.23	159	Y
Large alligator gar	12	3	21.62	176	Y

Trial	Salinity	Replicate	Length	Weight	Survival
Large alligator gar	12	4	21.66	173	Y
Large alligator gar	12	5	22.42	175	Y
Large alligator gar	12	6	19.96	170	Y
Large alligator gar	16	1	20.62	174	Y
Large alligator gar	16	2	22.33	171	Y
Large alligator gar	16	3	22.51	171	Y
Large alligator gar	16	4	20.19	166	Y
Large alligator gar	16	5	16.42	160	Y
Large alligator gar	16	6	18.59	162	Y
Large alligator gar	20	1	20.35	171	Y
Large alligator gar	20	2	23.49	178	Y
Large alligator gar	20	3	19.02	166	Y
Large alligator gar	20	4	15.26	151	Y
Large alligator gar	20	5	22.51	176	Y
Large alligator gar	20	6	18.35	168	Y
Large alligator gar	24	1	18.11	162	Y
Large alligator gar	24	2	18.82	164	Y
Large alligator gar	24	3	22.31	177	N
Large alligator gar	24	4	21.56	172	N
Large alligator gar	24	5	19.35	166	N
Large alligator gar	24	6	21.47	172	N
Large alligator gar	28	1	23.99	182	N
Large alligator gar	28	2	18.67	171	N
Large alligator gar	28	3	19.61	169	N
Large alligator gar	28	4	15.87	164	N
Large alligator gar	28	5	22.38	181	N
Large alligator gar	28	6	17.23	165	N
Large alligator gar	32	1	22.24	177	N
Large alligator gar	32	2	20.35	178	N
Large alligator gar	32	3	17.69	169	N
Large alligator gar	32	4	19.71	172	N
Large alligator gar	32	5	20.16	174	N
Large alligator gar	32	6	20.62	174	N

BIOGRAPHICAL SKETCH

Mark David Suchy was born on 3 September 1984 in Mandan, North Dakota. Marks childhood was spent interacting with nature on his parent's 4th generation family farm. His concern and respect for nature is deeply embedded from his father's education and his own work with nature. After graduating from Mandan High School in Mandan, North Dakota, Mark attended Bismarck State College for three semesters. After Bismarck State College, Mark transferred to North Dakota State University where he majored in Zoology, with an emphasis on fisheries and wildlife management, and Natural Resource Management, with an emphasis on biotic resources. Mark graduated North Dakota State University in December of 2007 and in January of 2008 he enrolled in Nicholls State University graduate program in Marine and Environmental Biology. Mark conducted research on the effect of salinity on growth and survival of larval and juvenile alligator gar *Atractosteus spatula*, and on plasma osmolality of non-teleost Actinoperygiian fishes. While at Nicholls Mark was a teaching assistant for one semester, and a research assistant with the NRCS for three semesters. After graduation in the fall of 2009, Mark will seek full time employment as a fisheries biologist.

CURRICULUM VITAE

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EDUCATION

M**. S. Marine and Environmental Biology. December 2009.** Nicholls State University, Thibodaux, Louisiana, 70310. Thesis title: Effects of salinity on growth and survival of larval and juvenile alligator gar *Atractosteus spatula*, and on plasma osmolality of non-teleost Actinoperygiian fishes

B. S. Zoology and Natural Resource Management. December 2007. North Dakota State University, Fargo, North Dakota, 58105.

TEACHING EXPERIENCE

January 2008 - May 2008: Teaching assistant, Nicholls State University, Department of Biological Sciences.

RESEARCH ASSISTANT

August 2008 – December 2009: Research assistant, Nicholls State University, Department of Biological Sciences.

RESEARCH EXPERIENCE

January 2008 – December 2009: Effects of salinity on growth and survival of larval and juvenile alligator gar, *Atractosteus spatula*, and on plasma osmolality of non-teleost Actinoperygiian fishes.

January 2008 – December 2009: Aquaculture of alligator gar *Atractosteus spatula* in recirculating systems.

January 2008 – August 2008: Zebra mussel *Dreissena polymoroha* survey of Bayou Lafourche, Louisiana.

EMPLOYMENT

January 2008 – December 2009: Graduate research assistant, Nicholls State University, Thibodaux, Louisiana. Conduct research on non-teleost fish species, including gill netting, boat operation, up to 24 feet, experimental tank and project design, spawning, growth trials, plasma osmolality trials, LC50 trials, fish weights and lengths, fish grading, screen/treat for disease and basic daily care, including monitoring total ammonia and nitrite levels, monitoring DO, pH, specific conductance, and salinity levels of all research animals. Collect, maintain, and analyze large date sets. Other experience gained during graduate school includes, native and invasive mussel collection and identification, oyster recruitment, coastal restoration projects, and yellow bass collection.

January 2008 – December 2009: Fisheries technician, Golden Ranch Plantation, Gheens, Louisiana. Assist with brood stock collection, husbandry, and growth and care of juvenile and adult alligator gar. Collect adult brood stock using multifilament gill nets and subsamples of juvenile stock to determine growth. Take routine water quality samples and perform daily feeding and care of juvenile alligator gar.

August 2008 – December 2009: Research assistant, Natural Resource Conservation Service, Thibodaux, Louisiana. Care, cultivate, and harvest marsh and coastal plants for restoration projects. Use a multitude of tractors and attachments to cultivate plot areas. Transplant various woody and herbaceous species. Use controlled burning techniques to eliminate detritus.

May 2007 – August 2007: Research assistant, Forestry Service, Steamboat Springs, Colorado. Navigate through mountain terrain using topography maps, GPS units, and compassing to search for endangered and sensitive species and analyze habitat for species presence. Identified a multitude of different avian species using aural, visual, or feather molts. Conducted point and call back surveys. Camped for extended periods of time in the wilderness.

May 2006 – August 2006: Research assistant, United States Geological Survey, Jamestown, North Dakota. Travel the Missouri River system searching for Piping Plovers and Least Terns. Collected fish and identify samples using benthic trawl and searched for nests and collected habitat samples using meter square. Utilized trimble, flow meter, and turbidity meter. Certified motorboat operator.

May 2005 – August 2005: Research assistant United States Geological Survey, Jamestown, North Dakota. Assisted a scientist with research on upland birds in rough terrain and varying weather conditions. Viewed and identified various bird species, both visually and aurally in natural habitats. Used GPS units and quadrant layout and read topographic maps on a daily basis.

September 2005 – May 2006: Research assistant, North Dakota State University, Fargo North Dakota. Assisted graduate students and professors with tasks associated with several different research projects. Increased time-management skills through feeding and caring for cattle. Worked in a controlled research environment utilizing experimental procedures and design. Operated heavy equipment in confined areas to accomplish research responsibilities.

May 2004 – October 2004: Biological science aide, United States Department of Agriculture, Mandan, North Dakota. Assisted a Rangeland Scientist with research associated tasks. Assisted in sample collection and experimental design layout and maintained research facilities through the upkeep of corrals, fences, and buildings. Certified operator of bobcat, pay loader, front-end loader, tractor, trailers, and ATV.

January 1994 – May 2005: Farm Technician, Suchy Dairy, Mandan, North Dakota. Screened, treated, and cared for dairy and beef cattle daily. Inspected, maintained, and operated equipment such as tractors, bobcats, and dairy machinery.

PUBLICATIONS

Timothy Clay, **Mark Suchy**, Wendell Lorio, Allyse Ferrara, and Quenton Fontenot. (*In Review*) Early growth and survival of larval alligator gar *Atractosteus spatula*, reared on artificial floating feed with or without a live *Artemia* spp. supplement. Journal of World Aquaculture Society.

PROFESSIONAL PRESENTATIONS

2009 Quenton Fontenot, **Mark Suchy**, Timothy Clay, Ricky Campbell Wendell Lorio, and Allyse Ferrara. Effects of ambient salinity plasma osmolality of juvenile alligator gar *Atractosteus spatula*, spotted gar *Lepisosteus oculatus*, Paddlefish *Polyodon spathula*, and lake sturgeon *Acipenser fulvescens*. 26 September 2009. World Aquaculture Society, Veracruz, Mexico.

2009 **Mark Suchy**, Timothy Clay, Wendell Lorio, Allyse Ferrara, and Quenton Fontenot. Effects of salinity on growth survival and cannibalism of juvenile alligator gar *Atractosteus spatula*. 12 September 2009. Annual Calypseaux Expedition of the Department of Biological Sciences of Nicholls State University, Thibodaux, LA.

2009 Timothy Clay**, Mark Suchy,** Wendell Lorio, Gary LaFleur, Allyse Ferrara, and Quenton Fontenot. Aquaculture of alligator gar *Atractosteus spatula* in recirculating systems. 12 September 2009. Annual Calypseaux Expedition of the Department of Biological Sciences of Nicholls State University, Thibodaux, LA.

2009 **Mark Suchy**, Timothy Clay, Wendell Lorio, Allyse Ferrara, and Quenton Fontenot. Effects of salinity on growth and plasma osmolality of juvenile alligator gar *Atractosteus spatula*. 26 March 2009. Research week poster competition, Nicholls State University, Thibodaux LA (poster presentation).

2009 Timothy Clay**, Mark Suchy,** Wendell Lorio, Gary LaFleur, Allyse Ferrara, and Quenton Fontenot. Aquaculture of alligator gar *Atractosteus spatula* in recirculating systems. 26 March 2009. Research week poster competition, Nicholls State University, Thibodaux LA (poster presentation).

2009 **Mark Suchy**, Timothy Clay, Wendell Lorio, Allyse Ferrara, and Quenton Fontenot. Effects of salinity on growth and plasma osmolality of juvenile alligator gar *Atractosteus spatula*. 27 February 2009. Louisiana Academy of Science, Hammond, LA. **2nd place best graduate student oral presentation.**

2009 Timothy Clay**, Mark Suchy,** Wendell Lorio, Gary LaFleur, Allyse Ferrara, and Quenton Fontenot. Aquaculture of alligator gar *Atractosteus spatula* in recirculating systems. 27 February 2009. Louisiana Academy of Science, Hammond, LA.

2009 **Mark Suchy**, Timothy Clay, Wendell Lorio, Allyse Ferrara, and Quenton Fontenot. Effects of salinity on growth and plasma osmolality of juvenile alligator gar *Atractosteus spatula*. 16 February 2009. World Aquaculture Society, Seattle, WA (poster presentation).

2009 Timothy Clay**, Mark Suchy,** Wendell Lorio, Gary LaFleur, Allyse Ferrara, and Quenton Fontenot. Aquaculture of alligator gar *Atractosteus spatula* in recirculating systems. 16 February 2009. World Aquaculture Society, Seattle, WA (poster presentation).

2009 **Mark Suchy**, Timothy Clay, Wendell Lorio, Allyse Ferrara, and Quenton Fontenot. Effects of salinity on growth and plasma osmolality of juvenile alligator gar *Atractosteus spatula*. 17 January 2009. Sothern Division, American Fisheries Society, New Orleans, LA.

2009 Timothy Clay**, Mark Suchy,** Wendell Lorio, Gary LaFleur, Allyse Ferrara, and Quenton Fontenot. Aquaculture of alligator gar *Atractosteus spatula* in recirculating systems. 17 January 2009. Sothern Division, American Fisheries Society, New Orleans, LA.

2008 **Mark Suchy**, Timothy Clay, Wendell Lorio, Allyse Ferrara, and Quenton Fontenot. Effects of salinity on growth and plasma osmolality of juvenile alligator gar *Atractosteus spatula*. 24 October 2008. Annual Calypseaux Expedition of the Department of Biological Sciences of Nicholls State University, Thibodaux, LA.

2008 Timothy Clay**, Mark Suchy,** Wendell Lorio, Gary LaFleur, Allyse Ferrara, and Quenton Fontenot. Aquaculture of alligator gar *Atractosteus spatula* in recirculating systems. 24 October 2008. Annual Calypseaux Expedition of the Department of Biological Sciences of Nicholls State University, Thibodaux, LA.